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COMMON FRINGE LILY

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SULPHUR TUFT

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RED CAGE FUNGUS

LUMPY BRACKET

PENNY BUN

BAROMETER EARTHSTAR

VIOLET CORAL

NATURAL HISTORY

THE ULTIMATE VISUAL GUIDE TO EVERYTHING ON EARTH

ORANGE-BARRED SULPHUR

COMMON GREEN SHIELD BUG

WART-HEADED BUG

FLAME SKIMMER

GOLD BEETLE

QUEEN ALEXANDRA'S BIRDWING

FIRE BUG

ADONIS BLUE

COMMON KESTREL

ROCKHOPPER PENGUIN

PURPLE GALLINULE

PLUMED WHISTLING DUCK

SCARLET IBIS

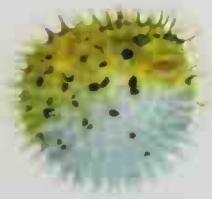
COMMON KINGFISHER

BARN OWL

YELLOW-COLLARED LOVEBIRD

FRILLED LIZARD

STRIPED HYENA


PORCUPINEFISH

AARDVARK

CRESTED PORCUPINE

COMMON SQUIRREL MONKEY

SMITH'S REED FROG

TIGER

SMITHSONIAN NATURAL HISTORY

What if our planet's kaleidoscope of life could be contained within the covers of a book? The result would be something very close to *Natural History*. Page after page displays a dazzling array of species from around the globe. From bacteria to bison, giant redwoods to ruby-throated hummingbirds, tripe fungi to trumpetfish, this is a unique record of the rich diversity of life on Earth.

LIVING EARTH

A fully illustrated introduction explains the story of our planet, from the unique conditions that first sustained life, to the evolution and classification of organisms that exist today. A specially designed "tree of life" charts the complex and interconnected relationships between species.

EXTRAORDINARY DIVERSITY

At the heart of the book is a breathtaking visual catalog with more than 5,000 full-color entries. In addition to plants, animals, fungi, and microscopic life forms, this encyclopedic directory also covers rocks, minerals and fossils, providing an unparalleled survey of the natural world.

LOOK CLOSER

Specially commissioned photographic features zoom in on single specimens, drawing readers into close encounters with some of Earth's most spectacular species.

Perfect for the entire family, from students to amateur naturalists, *Natural History* is a testament to the beauty of our world and an inspiration to conservationists everywhere.

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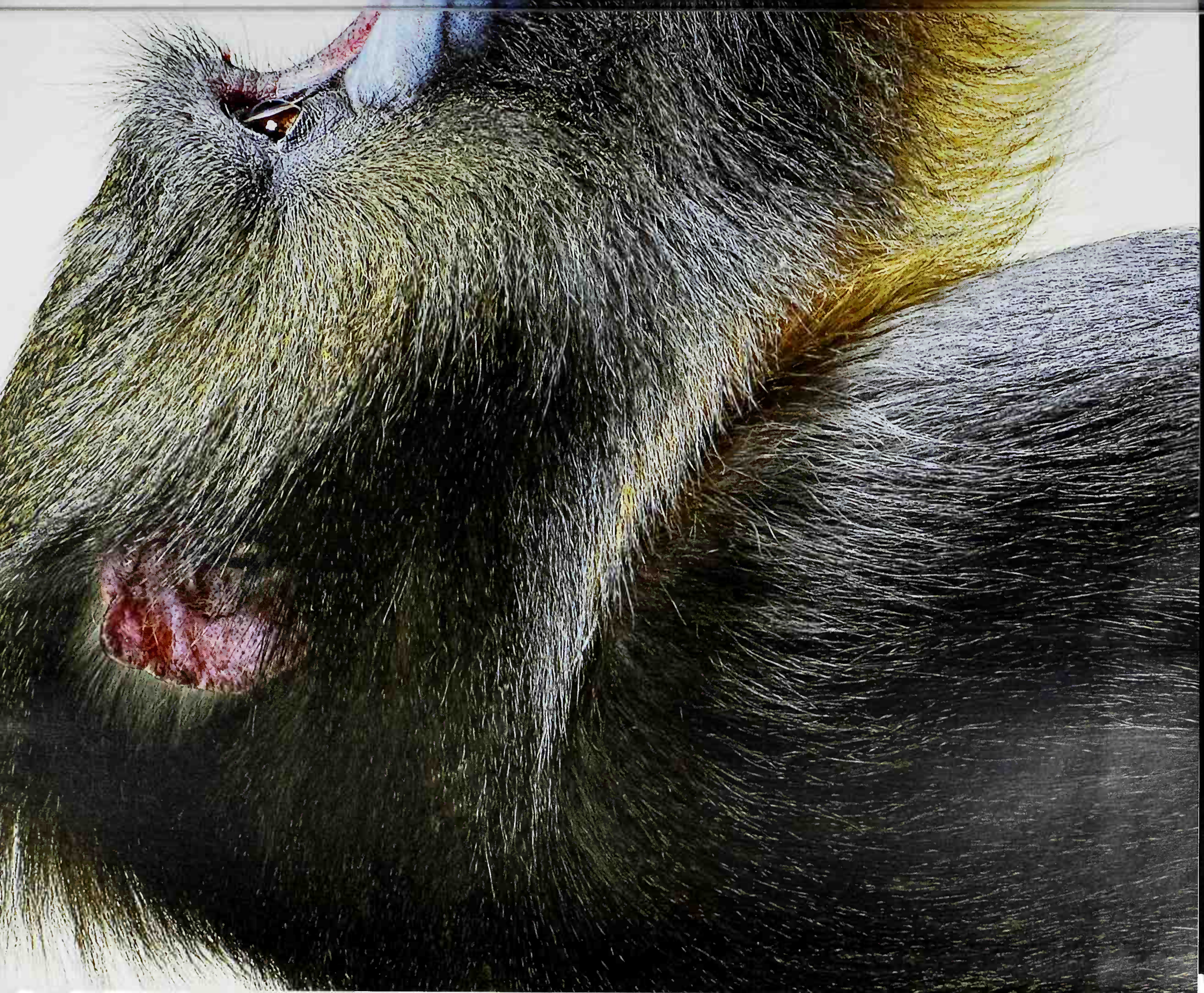

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THE ULTIMATE VISUAL GUIDE TO EVERYTHING ON EARTH

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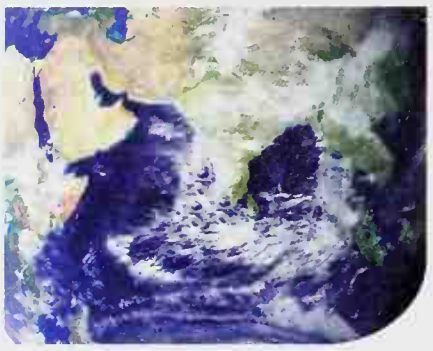

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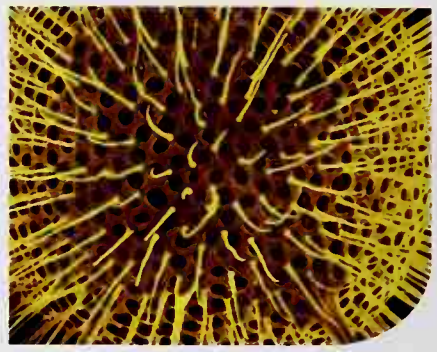

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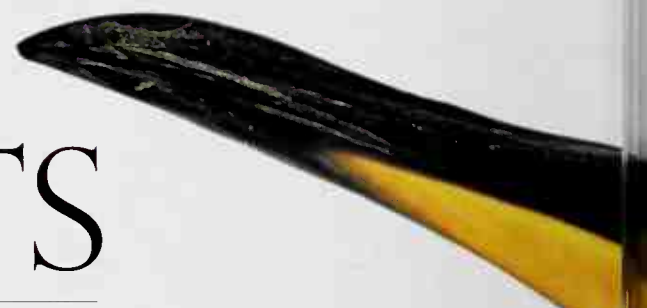

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Established in 1846, the Smithsonian Institution—the world's largest museum and research complex—includes 19 museums and galleries and the National Zoological Park. The total number of objects, works of art, and specimens in the Smithsonian's collections is estimated at 137 million, the bulk of which is contained in the National Museum of Natural History, which holds more than 126 million specimens and objects. The Smithsonian is a renowned research center, dedicated to public education, national service, and scholarship in the arts, sciences, and history.

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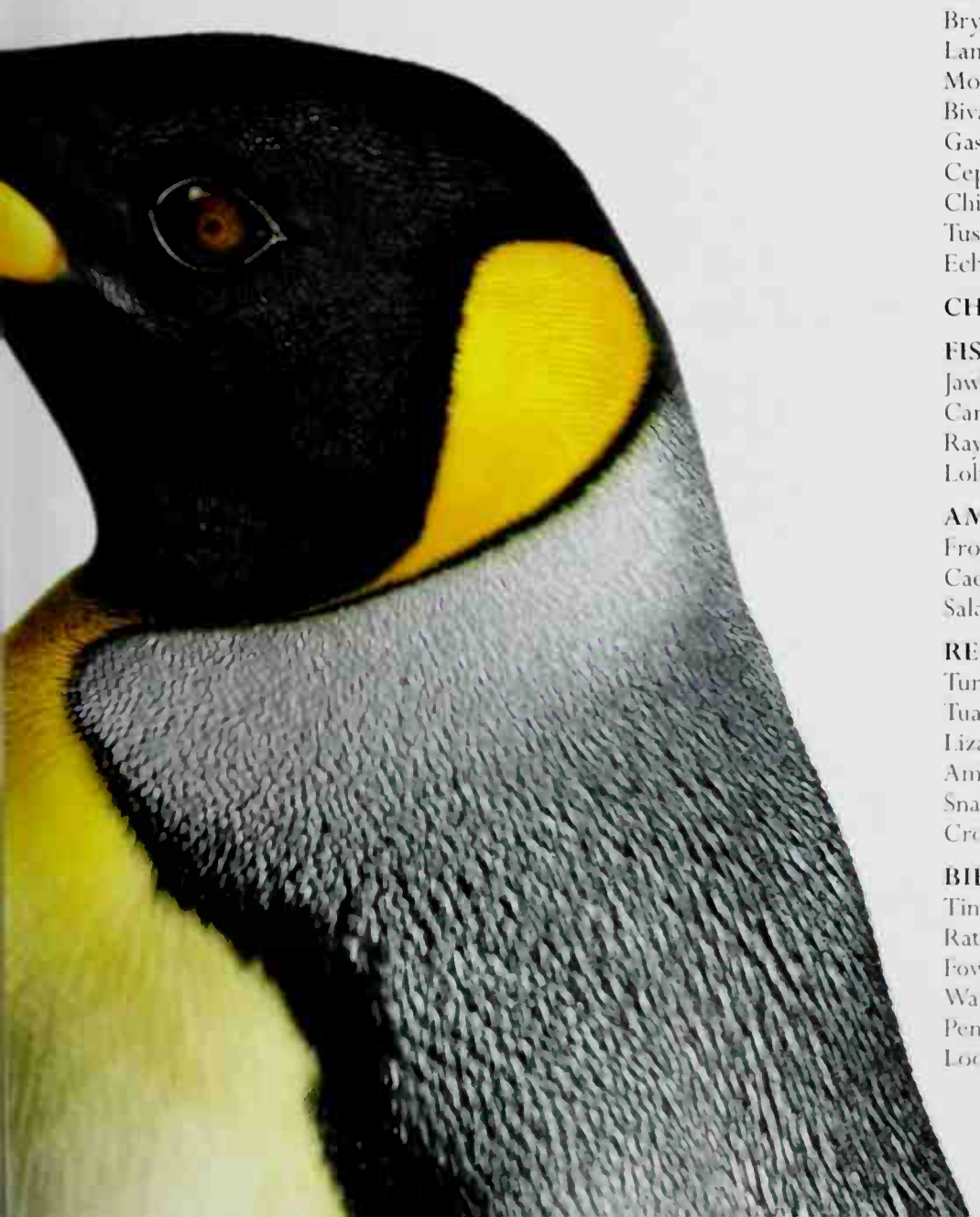

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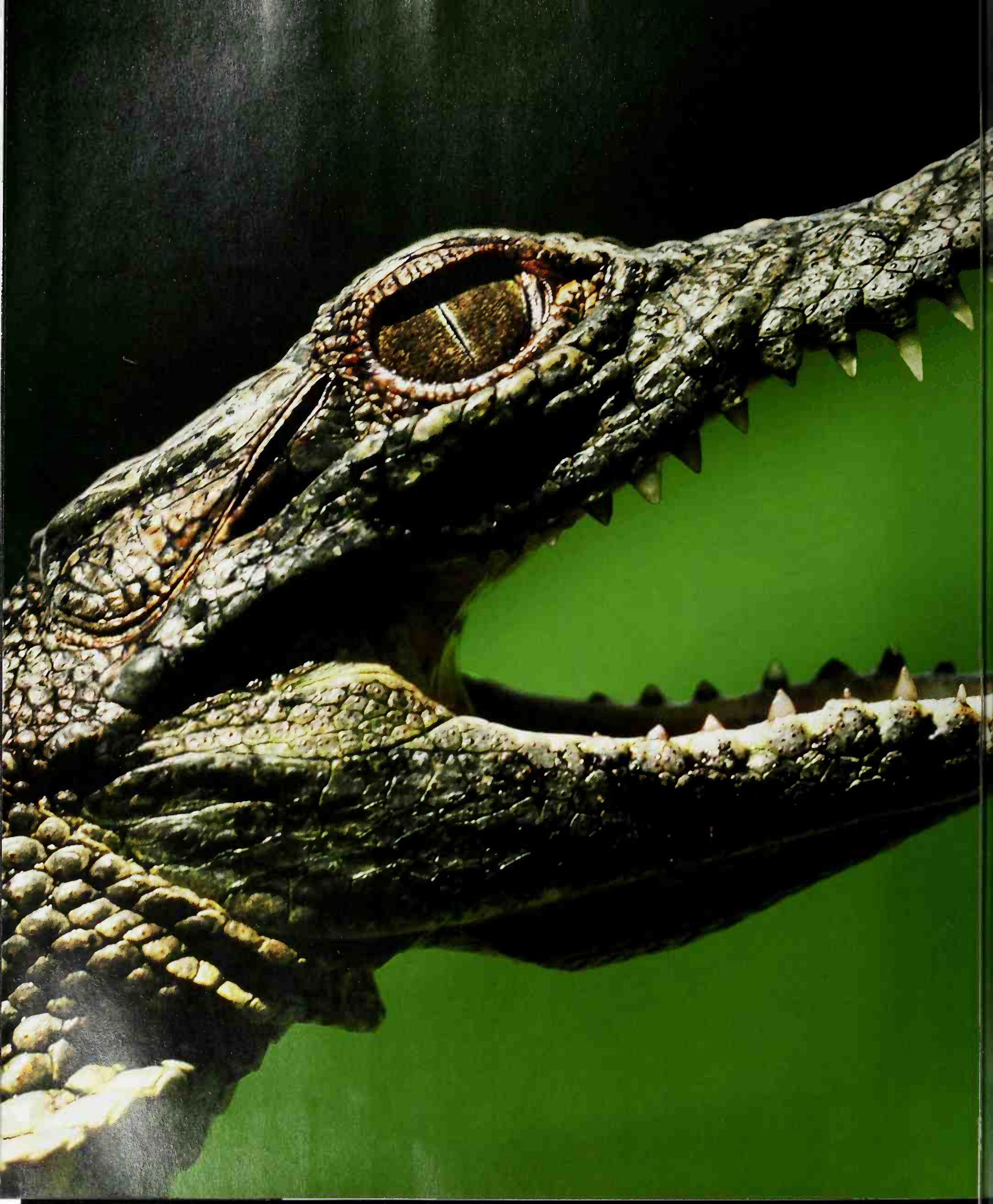


FOREWORD

We share this planet with millions of species of plants, animals and microorganisms, and our lives are intimately tied to them. Just take a moment to look around you and you will see that we are interacting with them every day, from the food we eat and the clothes we wear to the microbes that live inside our bodies, the air we breathe, and the water we drink. We are one small twig in a large and complex tree of life, a tree where most of the branches have been lost over time.

This book provides a window into the remarkable diversity and natural history of the world around us. It has been a long journey, going back 4.6 billion years to the formation of planet Earth itself. Although astronomers have discovered several hundred planets in other solar systems over the past decade, our home is unique given its location in the solar system, its geological history, and the evolution of life. Any one of these things could have changed and we would not be here today.

The study of these species, and the interactions among them and with their surrounding environment, is our own natural history. More than 1.9 million living species have been described to date, and more than 20,000 new species are discovered and described every year. Each one of them has a unique story, and is the result of millions of years of evolution through natural selection and adaptation to their environment. Their lives are intertwined into a gigantic web of life, with multiple, constantly changing connections between them. We are just one species, albeit one that is having an ever-increasing impact on this planet and beyond.

Fossils give us a rare window into the past, a form of time travel if you wish. We know that most species that have lived in the past 530 million years have become extinct, and that there have been mass extinctions when as many as 90 percent of all species disappeared. For example, fossil leaves from Wyoming show evidence of rapidly changing environments, from temperate grasslands to tropical forests, in the same place over time. Some of the fossil leaves even show the bite marks left by feeding insects 50 million years ago. By comparing these fossil communities in space and time we can see that species and their natural history have continuously responded to environmental change. Some of them made it; most did not. The study of these changes may give us insights into the past, present, and future of life on Earth.

The publication of this book coincides with the centennial anniversary of the Smithsonian's National Museum of Natural History. Our collections are pages of a gigantic encyclopedia of life, and the story is told through the insights of our scientists and educators. I trust you will enjoy this magnificent volume and accept it as an invitation to explore the Smithsonian and to explore the natural history of the world around you.

CRISTIÁN SAMPER

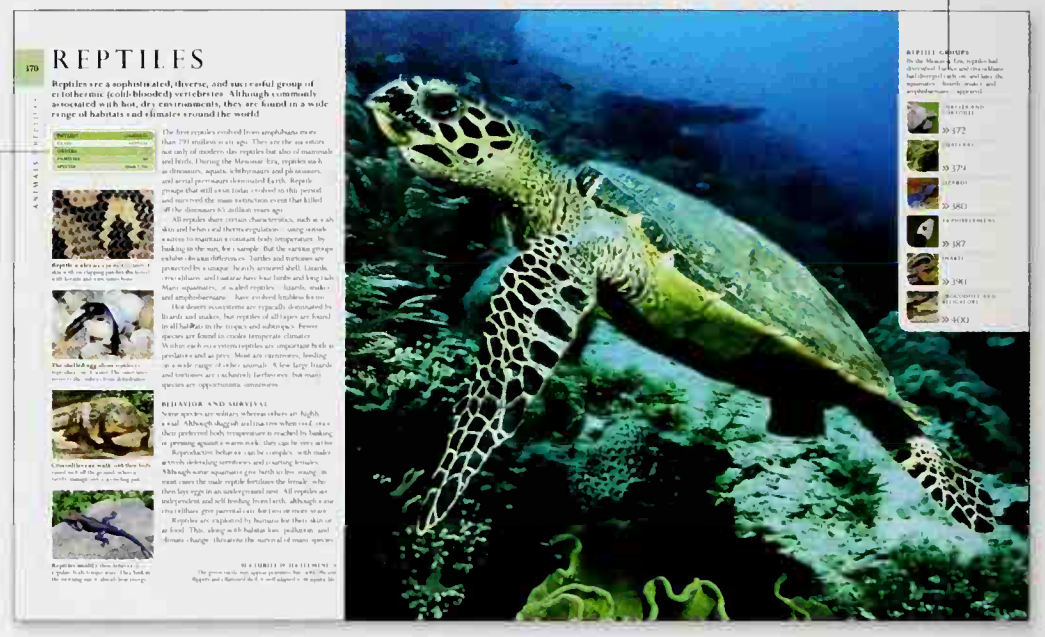
DIRECTOR, NATIONAL MUSEUM OF NATURAL HISTORY,
SMITHSONIAN INSTITUTION

ABOUT THIS BOOK

Natural History **begins with a general introduction to life on Earth: the geological foundations of life, the evolution of life forms, and how organisms are classified. The next five chapters form an extensive and accessible catalog of species and specimens—from mineral to mammals—interspersed with fact-filled introductions to each group and in-depth feature profiles.**

for easy reference, visual contents panels list the subgroups within each section, and the page number where each subgroup can be found

SECTION INTRODUCTION >
Each chapter is divided into sections representing major taxonomic groupings. The section introduction highlights the characteristics and behaviors that define the group, and discusses their evolution over time.

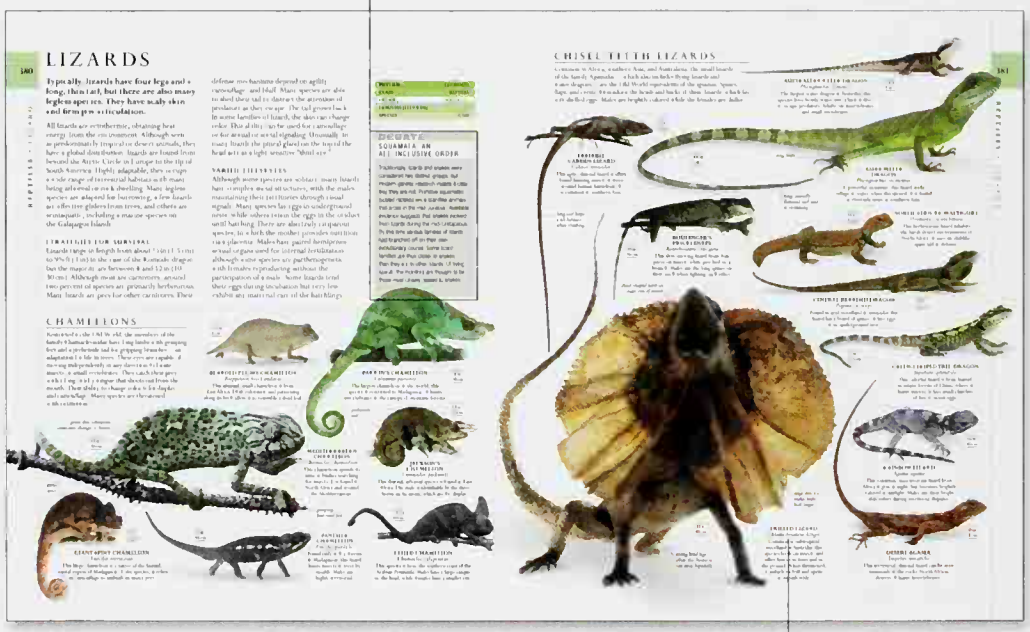


on each introduction, classification boxes display the current taxonomic hierarchy: the level of the group under discussion is highlighted

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDERS	4
FAMILIES	60
SPECIES	About 7,700

debate boxes tackle scientific controversies and taxonomic discussions arising from new discoveries

a male of the species ♂ *a female of the species* ♀



^ GROUP INTRODUCTION
Within each section—for example, reptiles—lower-ranking taxonomic groups, such as lizards, are explored. Key features are described, including their distribution, habitat, physical characteristics, life cycle, behavior, and reproductive habits.

species-specific information accompanies each image

SPECIES CATALOG >
Pictorial galleries profile around 5,000 species, showing the distinctive visual features of each one. Closely related species are placed together for useful comparison, while essential data highlights unique and interesting apsects of each organism.

data sets display key details at a glance, such as size, habitat, distribution, and diet

SIZE 4½–9¾ ft (1.4–2.8 m)
HABITAT Forests, swamps, scrub thickets, savanna, and rocky landscapes
DISTRIBUTION India to China, Siberia, the Malay peninsula, and Sumatra
DIET Mainly hoofed animals, such as deer and pigs, may also catch smaller mammals and birds

v FEATURE PROFILE
Zooming in on single specimens, feature profiles use close-up photographs to provide in-depth portraits of some of the world's most spectacular species.

each feature includes a side profile of the animal or plant

ST VINCENT PARROT
Amazona guildingii
F: Psittacidae

species' common names are highlighted in bold, scientific names are in italics; in some cases the family (F) name is given below

12 in
30 cm

size boxes give the most appropriate measurement for the organism they accompany (see panel, right)

DATA

MEASUREMENTS

The approximate sizes of the organisms in this book are given in data sets and size boxes. Below is a list of the dimensions used

MICROSCOPIC LIFE
Length

PLANTS
Maximum height above ground, except for:
Height above water rushes
Spread aquatic plants

FUNGI
Width (of widest part), except for:
Height stinkhorn, dog stinkhorn

INVERTEBRATES
Adult body length, except for:
Height sponges, feather stars, common hydra, feather hydroid, pink-hearted hydroid, fire "coral" hydroid, tall anemones, tall corals
Diameter snailfur, blue button, eight-ribbed hydromedusa, cup hydromedusa, freshwater jellyfish
Diameter, excluding spines echinoderms
Diameter of medusa jellyfish
Wingspan butterflies and moths
Length of colony bryozoans
Length of shell mollusks, shelled gastropods
Spread of tentacles octopuses

FISH, AMPHIBIANS, AND REPTILES
Adult body length from head to tail

BIRDS
Adult body length from bill to tail

MAMMALS
Adult body length, excluding tail, except for:
Height to shoulder elephants, apes, even-toed ungulates, odd-toed ungulates

PLANT ICONS

The basic shape of all trees, shrubs, and woody plants is described using one of the following symbols. Herbaceous perennials which die back each winter are not given symbols.

TREES
- Broadly columnar
- Broadly conical
- Large weeping
- Small weeping
- Multistemmed tree
- Narrowly columnar, flame-shaped
- Narrowly columnar
- Narrowly conical
- Rounded, broadly columnar
- Rounded, broadly spreading
- Single-stemmed palm
- Multistemmed palm, cycad or similar

SHRUBS
- Bushy, mound-forming
- Bushy, suckering
- Compact, bushy
- Erect, treelike
- Loose, open
- Open, spreading
- Rounded, bushy
- Spreading, prostrate
- Upright
- Upright, arching
- Upright, vigorous, bushy
- Sprawling, climbing

ABBREVIATIONS

SP: species (used where species name is unknown)
MYA: million years ago
H: hardness of a mineral, measured on the Mohs scale
SG: specific gravity—a mineral's density is measured by comparing its weight to that of an equal volume of water

LIVING EARTH

Our blue planet, spinning in the vastness of space, is the only proven home of living things. Over nearly four billion years, life has evolved from the simplest of beginnings. Many species have become extinct, but life itself has flourished and endlessly diversified. The result is an extraordinary variety of living things, which scientists continue to study as they piece together the story of life on Earth.

A LIVING PLANET

Earth is uniquely equipped to support a wide diversity of life, both on land and in the seas. Without heat and light from the Sun, plentiful supplies of water, the protection provided by the atmosphere, and the rocks and minerals that make up the basis of Earth's ecosystems, life would perish.

DYNAMIC EARTH

Within our Solar System, Earth seems to be uniquely placed to support abundant life. The third planet from the Sun, Earth is neither too close to nor too far from the Sun's heat. It therefore retains an outer atmosphere of oxygen and other gases, and a hydrosphere of plentiful surface water. Together, these form a protective, insulating layer that enables life to flourish. In contrast, the other planets in the Solar System are either too hot or too cold, and devoid of the levels of water and oxygen required to support detectable life.

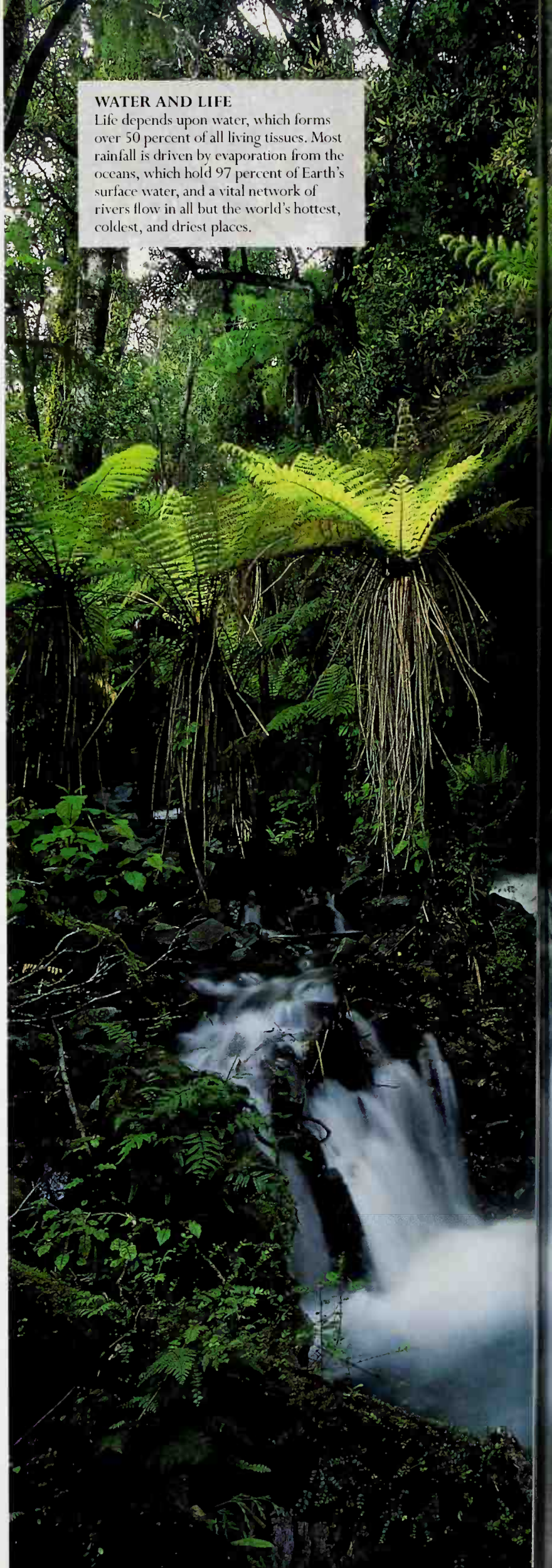
Earth has a layered structure, with an extremely hot, solid metallic core at its center, surrounded by an outer molten layer. This, in turn, is surrounded by a thick and hot silicate mantle, which rises to a thin, cool, and brittle outer crust. The mantle is constantly churned by heat rising from the core, and this puts pressure on the crust, which is broken into crustal "plates." Over geological time, the drift of these plates, both toward and away from one another, has changed Earth's geography and living environments. Oceans, mountains, and landscapes are constantly formed and destroyed, and life has had to adapt to these changes.

EARTH'S STRUCTURE >
The liquid mantle is constantly stirred by heat rising from the core. This moves the plates of the outer crust, causing earthquakes and volcanic eruptions on the surface.

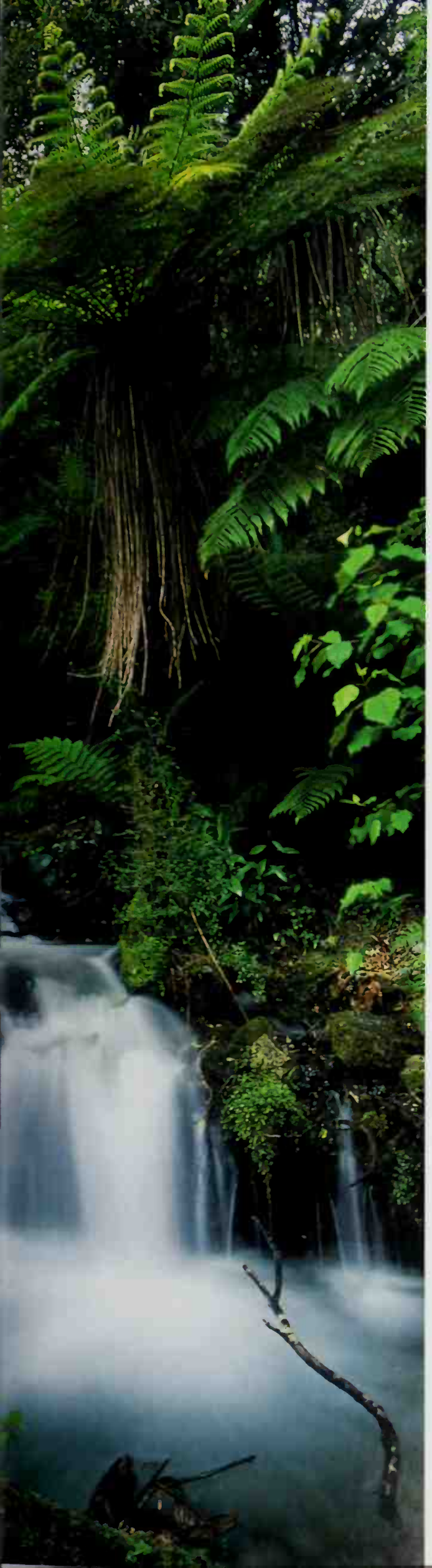
^ SOLAR FLARES
The Sun's energy is dramatically released from the surface in periodic explosions, which heat its atmosphere to form solar flares of hot ionized gas.

SUN AND MOON

The Sun and the Moon both have a direct impact on life on Earth. Without the Sun's energy, in the form of heat and light, there would be no life. Solar energy heats the atmosphere, the oceans, and the land, producing our varied climate. Because Earth rotates at an angle while it orbits the Sun, the Sun's radiant energy is unevenly distributed over Earth's surface. This results in daily, seasonal, and annual variations in light, heat, and living conditions for plants and animals. Even at the equator, there are marked temperature changes between day and night. The orbit of Earth's satellite moon and its gravitational pull raise tides in Earth's oceans and seas. Tidal cycles are especially influential on coastal life, which has to adapt to changing conditions.



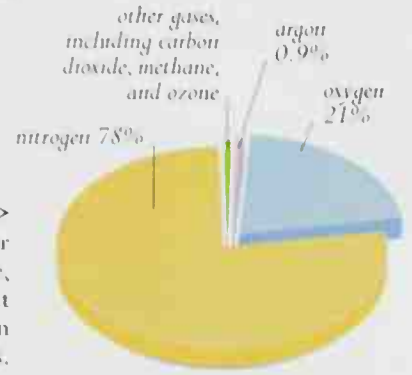
WATER AND LIFE
Life depends upon water, which forms over 50 percent of all living tissues. Most rainfall is driven by evaporation from the oceans, which hold 97 percent of Earth's surface water, and a vital network of rivers flow in all but the world's hottest, coldest, and driest places.



FRAGILE ATMOSPHERE

Earth's atmosphere is 75 miles (120km) thick. It is made up of several layers, each with its own temperature and gas composition. Its density decreases with height, until it becomes the sparse, outermost layer, called the ionosphere. The ozone layer, in the lower atmosphere, plays a vital role in protecting life because it absorbs harmful radiation such as ultra-violet light, which damages living cells. Before the ozone layer formed, life was confined to the seas, whose waters offered some protection against ultraviolet light.

The majority of water vapor and weather activity is restricted to the lowest 10 miles (16km) of atmosphere, known as the troposphere. Earth's surface water and gaseous atmosphere interact to recycle water from the surface into the atmosphere and—through clouds, rain, and snow—redistribute it over the land and sea. From the land, water flows back into the sea, although large quantities are held back in lakes, ice, and under the ground.



ATMOSPHERIC GASES >
Nitrogen and oxygen make up over 99 percent of Earth's atmosphere, along with small but important volumes of water vapor, carbon dioxide, and several other gases.

^ BLUE PLANET
Around two-thirds of Earth's surface is covered with water, which supports the abundance and diversity of life.

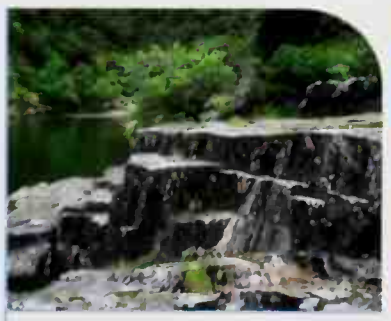
^ LAYERS OF ATMOSPHERE
Earth is surrounded by a thin, layered atmosphere, composed of water vapor and various gases, which trap solar energy and heat the surface.

VARIED ROCKS

There are around 500 different kinds of rocks on Earth, made up of varying combinations of thousands of naturally occurring minerals. All rocks have a specific composition and properties, and can be divided into three main categories: igneous rocks were originally molten; sedimentary rocks are deposited at Earth's surface; and metamorphic rocks result from the alteration of existing rocks within Earth's crust. These different types of rock are exposed on the surface by a mixture of uplift, driven by Earth's moving crust, and surface processes such as weathering and erosion. Erosion also modifies the rocks to produce multiple kinds of landforms, soils, and sediments. These are the inorganic elements on which life depends.

IGNEOUS ROCKS
The cooling and solidification of molten rock produces crystalline igneous rocks. Their composition and texture vary—rapid cooling produces fine grained rocks, and slow cooling produces coarse grained rocks.

BASALT



METAMORPHIC ROCKS
The application of heat and pressure to existing rocks deep within Earth's crust can change their form and mineral composition, resulting in metamorphic rocks such as slate, schist, and marble.

GARNET SCHIST

SEDIMENTARY ROCKS
Layers of sand and dead animal bones constantly settle on sea and river beds. After millennia buried under the weight of subsequent layers, and that of the water above them, these sediments compact and harden into rocks.

SANDSTONE

ACTIVE EARTH

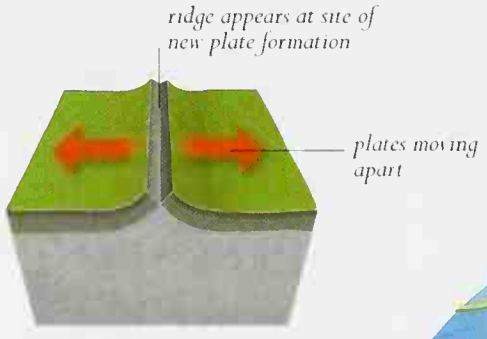
Earth's surface is constantly changing, thanks to dynamic geological processes driven by its internal heat energy. The plates of Earth's brittle outer crust are always in motion, altering the shape of oceans and continents as they do so.

PLATE TECTONICS

Over geological time, Earth's surface—and the distribution and size of the continents and oceans—has constantly changed, driven by the process of plate tectonics. The cool and brittle rocks of Earth's outermost crust are broken into a number of semirigid slabs known as tectonic plates. There are seven major continent-sized plates and about a dozen smaller ones. Over time, these crustal plates have been jostled against one another by the motion of the underlying mantle.

As plates are dragged apart, molten magma from the lower mantle forms new crust. This occurs at divergent boundaries, which are mainly beneath the oceans. And, since Earth itself cannot expand, the creation of new oceanic crust requires that the crust is shortened elsewhere by the same amount. This reduction occurs at convergent boundaries where either one plate overrides the other—a process known as subduction—or the plate margins are compressed and buckled to form mountains.

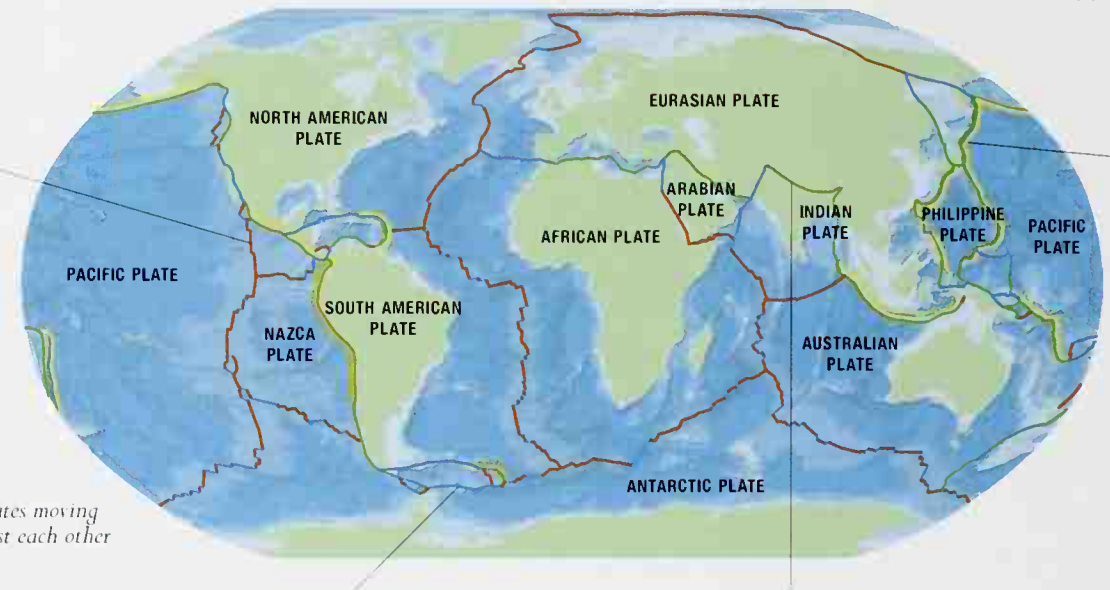
^ SAN ANDREAS FAULT
Stretching some 810 miles (1,300 km) through California, this dramatic fault is the product of a transform boundary between the Pacific and North American plates, which slide against one another.

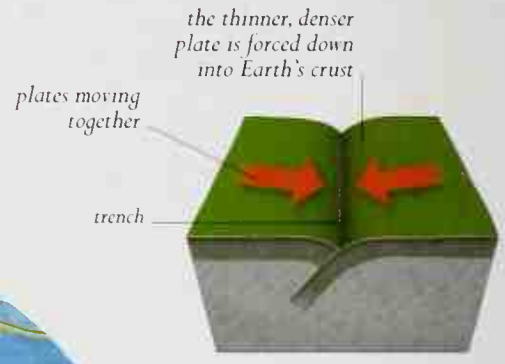


DIVERGENT BOUNDARY
As plates are pulled apart they stretch and break, forming faulted rifts and volcanically active ridges.

v PLATE BOUNDARIES
This map shows the main plates that form the jigsaw surface of Earth's crust. A study of earthquake locations worldwide established where the plate boundaries lie.

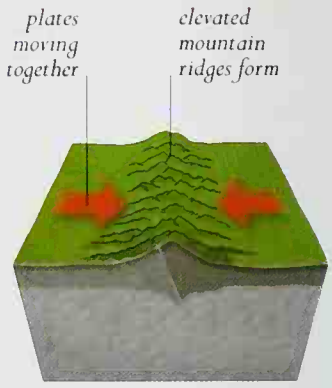
MAP KEY
- Convergent boundary
- Divergent boundary
- Deep-sea trench
- Transform boundary



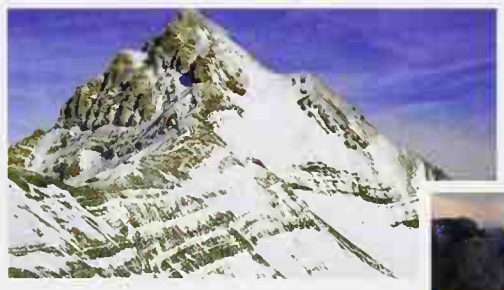


SUBDUCTION ZONE
Where two plates converge and one plate is thicker, it pushes the thinner plate beneath it in a process called subduction.

TRANSFORM BOUNDARY
Also known as conservative plate boundaries, these occur when two plates slide horizontally past one another, neither destroying or creating new crust.



CONVERGENT BOUNDARY
Where two converging plates are of similar density and thickness, their leading edges are crumpled, faulted, and thickened to form mountain ranges such as the Himalayas.



< FOLD MOUNTAINS
The intense pressure caused when plate margins converge can create an incredible folding and faulting of the crust as the rocks are pushed upward to form mountains.

ACTIVE VOLCANOES >
Most volcanoes form at plate margins. Deep down, rocks melt to produce hot magma which rises and erupts at the surface. Even dormant volcanoes may one day erupt as plates shift beneath them.

MOUNTAINS AND VOLCANOES

One of the major factors controlling the movement and distribution of life on Earth is its varied topography—its surface features—including the towering mountains and volcanoes on land and under the sea. On land, mountains not only hinder the movement of wildlife but also alter weather, climate, and local plant life, which in turn impacts animal life. Active volcanoes also affect their surroundings when they erupt—initially by destroying life, but also, in the longer term, when the weathering and erosion of erupted lava and ash provide new mineral nutrients that fertilize the area. Mountains under the sea affect the movement of marine life, and submarine volcanic eruptions affect the fertility of ocean waters.

WORN AWAY
Weathering by wind and water can result in the significant erosion of rocks and the sculpting of land surfaces, as seen here in the dramatic landscape of Bryce Canyon, Utah.

WEATHERING AND EROSION

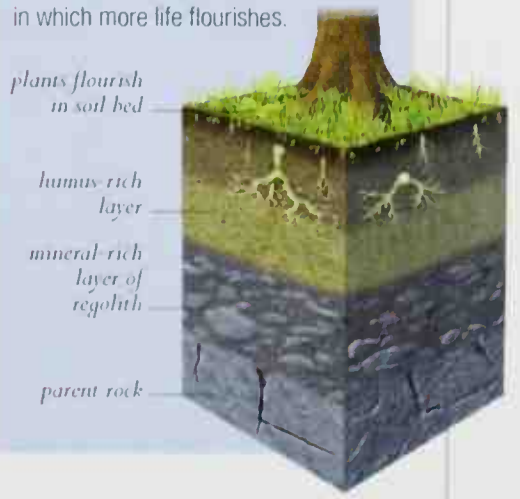
Many rocks are formed below Earth's surface, and when they are exposed by pressures in Earth's crust or by retreating seas or rivers, they react in many ways with the atmosphere, water, and living organisms. The physical and chemical processes resulting from the interaction of rocks and minerals with the atmosphere are known as weathering. The processes by which rock material is loosened, dissolved, and transported away is known as erosion. The combination of weathering and erosion wears down Earth's rocky surfaces, layer by layer. Exposed rocks on mountain tops and on the exterior of buildings, for example, are subject to chemical weathering by acid rain and to physical weathering by temperature change and the splintering freeze-thaw effect of ice formation. Bare rock surfaces may also be physically eroded by sand particles carried by the wind. The combined effect of weathering and erosion dissolves some rocks, and reduces others to fragments. As rock debris is broken down and transported by wind, water, and ice, the sediment created becomes increasingly available to life forms, providing important mineral nutrients and a new surface for anchorage and growth.

< LANDSLIDE, RIO DE JANEIRO
Even with a well-developed plant cover, the impact of high rainfall on an area of steep slopes has the potential to cause landscape-altering and even life-threatening occurrences such as avalanches and landslides.

SCIENCE

SOIL FORMATION

The production of a soil requires the initial weathering and erosion of the parent rock, which is broken down into small, mineral-bearing particles known as regolith. The addition of humus—organic matter formed from the remains of plants and animals—forms the basis for a soil. The soil in turn becomes the bed in which more life flourishes.

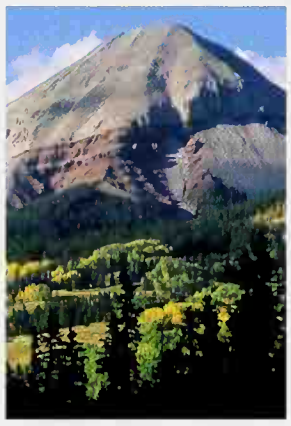


CHANGING CLIMATES

The features of our seasons—for example, hot, dry summers and cold, icy winters—make up the climate of each region. Earth's climate has always changed from place to place and over time, and this variation in conditions has considerable and continuing impact upon the evolution of life.

WHAT IS CLIMATE?

Climate is a region's average weather over a long period of time, produced by all the atmospheric conditions such as temperature, rainfall, wind strength, and pressure. The climate of any given place is also partly controlled by a number of other factors such as its height above sea level, local topography, proximity to seas and oceans—with their prevailing winds and water currents—and, most importantly, its latitudinal position between the equator and pole. Latitude controls the amount of solar radiation received in different regions of the world. For instance there is a major difference between climates of polar regions, which receive the least light and heat, and of tropical regions around the equator, which receive the most.



< CHANGING TREE LINE
As the air temperature declines with increasing altitude, plant life changes. Broadleaved trees are replaced by conifers, then shrubs.

CHANGING CONDITIONS

Global climates are generally classified according to the average temperature and the amount of rainfall each area receives, and their combined effect on plant growth. For instance, equatorial regions at present are hot and wet because oceans dominate there, whereas deserts are dry and polar regions are cold. However, this has not always been the case. Factors controlling weather conditions over geological time have affected the climate of the planet, from ice ages through to global warming.

ARCTIC FOX IN SUMMER

ARCTIC FOX IN WINTER

^ SEASONAL ADAPTATION
Annual climate change can bring acutely different living conditions from one season to the next. Animals and plants have various means of adapting to these changes; for example, the Arctic fox grows a thick coat in winter, which it sheds in summer.

LIFE IN THE DESERT
Plants such as cacti have adapted to life in semiarid environments by slowing growth, reducing the leaves to spines (to stop water loss from transpiration), and evolving special tissues that retain water.

< EVIDENCE OF CLIMATE CHANGE
Studies of polar ice core samples have revealed details of past climate change. The chemical analysis of trapped gas bubbles helps provide an approximate measure of the temperature of the atmosphere at the time the ice was formed.

< ICE CORE SAMPLE
This is a close-up of an ice core sample recovered from Lake Bonney, Antarctica, which has a permanent ice cover. It shows trapped bubbles of air and sediment particles from the lake bed.

CLIMATE CYCLES

There is clear evidence from rocks and fossils that Earth's climate has changed significantly over time and that this has affected the evolution and distribution of life, and led to the extinction of many species. There are a number of causes of this natural climate change, including volcanic activity, which pollutes the atmosphere with ejected gas and dust, and changes in ocean currents, which move heat around the globe. Change is also driven by the orbital and rotational cycles of the planet, which affect the amount of solar radiation that reaches Earth's surface. This influences the planet's temperature and climate, and triggers Earth's cycles of ice ages and greenhouse periods.

CHANGING GEOGRAPHY

Over time, continents have been displaced as oceans have expanded and contracted due to plate tectonics. As continents moved from one hemisphere to another they passed through different climatic zones and, at times, formed supercontinents. The size of these huge landmasses affected regional climates. In addition, the changing shape of ocean basins has altered water circulation, which in turn changes the temperature and humidity of the atmosphere above, and so affects climate.

GREENHOUSE AND ICE AGES

Long-term changes in climate are divided into cold periods—ice ages, when there were long-lasting ice sheets at the poles—and warmer, greenhouse periods with largely ice-free poles. Warm phases are linked to the release of greenhouse gases, such as carbon dioxide, by plants into the atmosphere. These trapped heat in Earth's atmosphere and produced huge, shallow seas, arid zones, and lush forests that, in the time of the dinosaurs, provided them with plentiful food. Ice ages, lasting millions of years, can be traced from the impact that glaciation has left on the landscape. Fossils show how rapid climate change associated with ice ages had a dramatic impact upon life on a global scale.

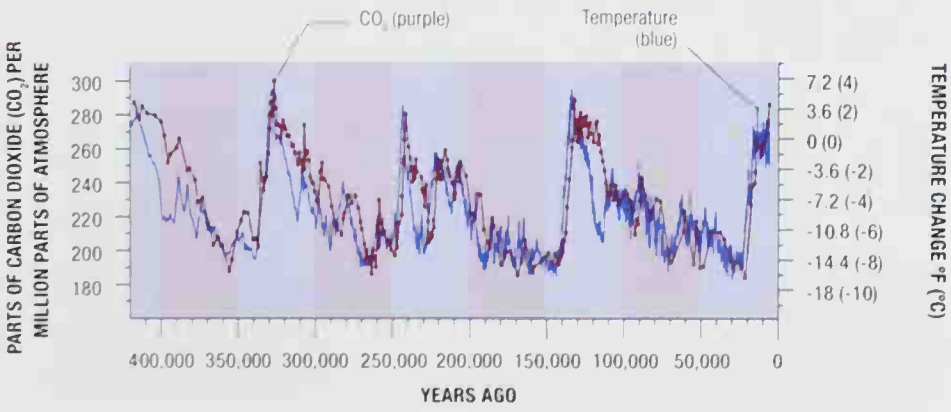
SCIENCE
STUDYING STOMATA

Plant growth depends upon an exchange of gases between the atmosphere and the plant tissue, through special gaps between the leaves' cells called stomata. The stomata open and close to take in carbon dioxide for photosynthesis and allow waste water and oxygen to escape. In general, plants adapt to high levels of atmospheric carbon dioxide, associated with warm "greenhouse" climates, by evolving high densities of stomata on the leaf surface. Fossil evidence of changes in the stomatal density of certain plants tracks changes in atmospheric carbon dioxide over time.

EUCALYPTUS STOMATA

^ DEVONIAN CORAL REEF
Earth's changing climate is illustrated by this limestone outcrop in The Kimberleys, Western Australia. In the Devonian Period (400 million years ago), the area was under water and the cliff was a barrier reef.

v CARBON DIOXIDE AND TEMPERATURE
Gas bubbles trapped in polar ice cores indicate the fluctuating temperature of the planet—the higher the amount of carbon dioxide detected in the ice core, the higher the atmospheric temperature would have been at that time.



HABITATS FOR LIFE

Earth's uniquely varied habitats enable it to support an abundantly rich diversity of animal and plant life—from the extreme depths of the ocean floors to the highest mountains, and from arid deserts and grasslands to the warm, wet tropics.

Each life form has its preferred habitat—the one to which it has adapted over thousands or even millions of years. However, Earth's varied environments allow many different kinds of animals and plants to live in the same habitat—a phenomenon known as biodiversity. As life evolved and diversified over geological time, it was able to extend beyond the seas and colonize more and more of Earth's different land habitats. The presence of these pioneering organisms in turn produced changes in the environments they colonized, by forming soils for instance, and these modifications encouraged further colonization by new life forms.

Differences in habitats are produced by many factors, ranging from an area's height above sea level, its distance from the equator, and its topography (or physical shape). Some areas of the globe are biodiversity "hotspots," rich in animal and plant life—most notably tropical reefs and rain forests—while other areas with more extreme conditions support only a few, though often heavily populated, species.

SCIENCE
LEVELS OF LIFE

Organisms rarely exist entirely on their own, even in the remotest places on Earth. The interactions between wildlife create different levels—from the individual organism to the overall ecosystem that it inhabits and shares with others.

INDIVIDUAL
A single, usually independent and habitat-restricted member of a population.

POPULATION
A group of individuals of the same species that occupy the same area and interbreed.

COMMUNITY
A naturally occurring collection of plant and animal populations living within the same area.

ECOSYSTEM
A biological community and its physical surroundings, which support one another.

KEY

- Polar region
- Desert
- Grassland
- Tropical forest
- Temperate forest
- Coniferous forest
- Mountains
- Coral reef
- Rivers and wetland
- Oceans

MAP OF BIOMES
A biome unites ecosystems that have developed under similar climatic and soil conditions in different parts of the world. Biomes are defined by a variety of factors such as plant types, climate, geology, and topography.

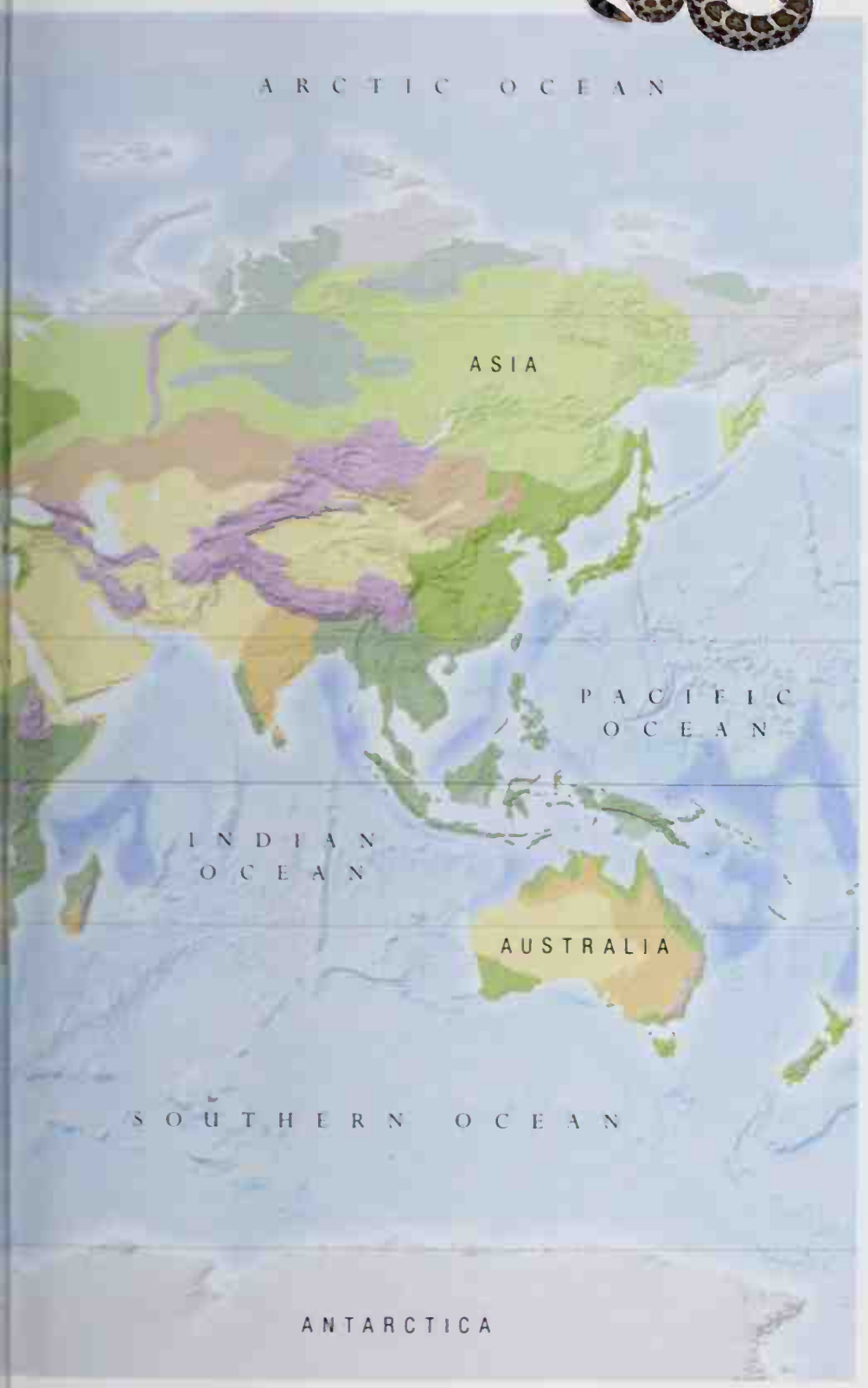
GRASSLAND
The evolution of grass plants some 20 million years ago, and the colonization by grazing mammals, transformed Earth's landscapes. Temperate grasslands are generally treeless and have extremely fertile soils. Savanna grasslands, as shown here, are more like open woodland, featuring scatterings of trees and scrubs.

BISON

DESERT

Extreme lack of rain and soils for sustained plant growth creates deserts, which at present account for about a third of Earth's landscapes, although this proportion is increasing. The largest desert is the African Sahara.

RATTLESNAKE



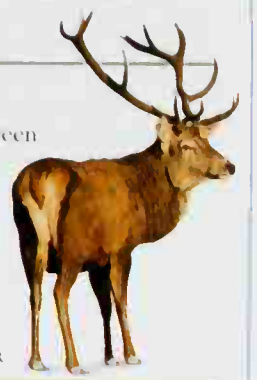
TROPICAL FOREST

The richest wildlife habitats on land are found in the forests of the tropics — Earth's hottest areas, which lie by the equator. Their numerous ecosystems are important yet increasingly vulnerable biodiversity hotspots.

STRAWBERRY POISON DART FROG

TEMPERATE FOREST

Temperate environments lie between the tropics and the polar regions. The influence of both tropical and polar air masses promotes vast forests with considerable biodiversity. However, clearing by humans has greatly reduced their extent.



RED DEER

CONIFEROUS FOREST

Coniferous forest trees, such as redwoods, spruce, and fir, belong to an ancient plant group and are the world's toughest trees. Evergreen with small leaves, they thrive where few other trees can, in cold areas and in mountain ranges.

BROWN BEAR

MOUNTAINS

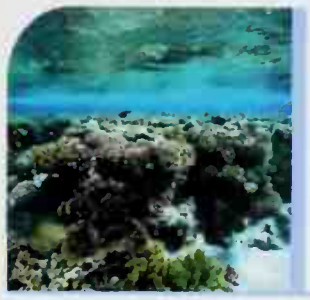
Reaching as high as 5½ miles (9 km) above sea level, Earth's mountains are home to many different environments. A single mountain can rise from temperate woodland up to arctic conditions as the climate changes with altitude.

PEREGRINE FALCON

RIVERS AND WETLAND

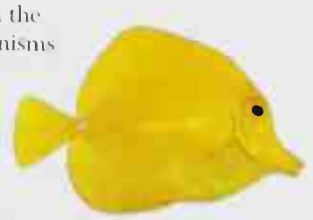
A wide range of animal and plant life thrives in Earth's rivers and lakes. Landscapes saturated with water, either permanently or seasonally, form distinctive wetlands, where areas of open water mix with dense vegetation.

DRAGONFLY



CORAL REEF

Coral reefs develop from the skeletons of marine organisms in shallow, sunlit tropical waters. Supporting an immense variety of life, they are the rain forests of the aquatic world.



YELLOW TANG FISH

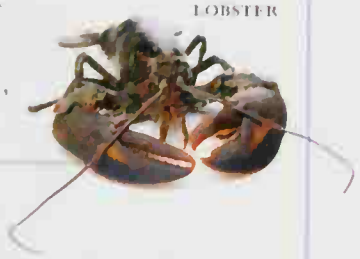
POLAR REGIONS

The Arctic and Antarctic experience extreme seasons, with 24-hour daylight in summer and perpetual darkness in winter. They are dominated by large amounts of snow and ice, but also contain vast, dry areas of polar desert, which receive little annual rainfall.

ROCKHOPPER PENGUIN

OCEANS

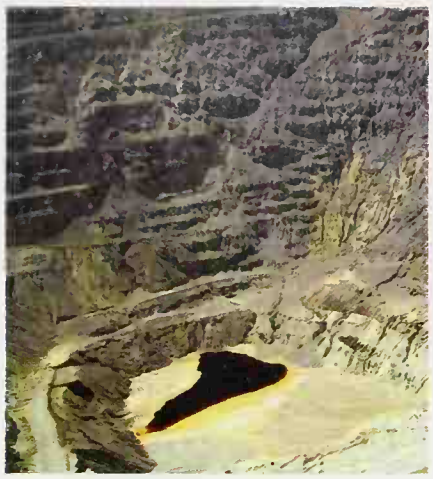
Life in oceans is found at all levels, from the sunlit surface to the deepest depths. Covering two-thirds of the planet, oceans form the largest continuous habitat on Earth and support very varied life forms — from microscopic plankton to the largest living mammal, the blue whale.



LOBSTER

HUMAN IMPACT

The rapid growth of the human population has had an enormous impact upon Earth's natural environments, affecting the climate and countless species of plant and animal life. Some of these changes are irreversible.



^ **SCARRED LANDSCAPE**
The growth of industry has required the exploitation of raw materials. Their extraction, such as at this copper mine, has changed global landscapes forever.

^ **ATMOSPHERIC POLLUTION**
Slash-and-burn forest clearing for agriculture not only releases atmospheric pollutants but also diminishes the capture of carbon dioxide by the plant life.

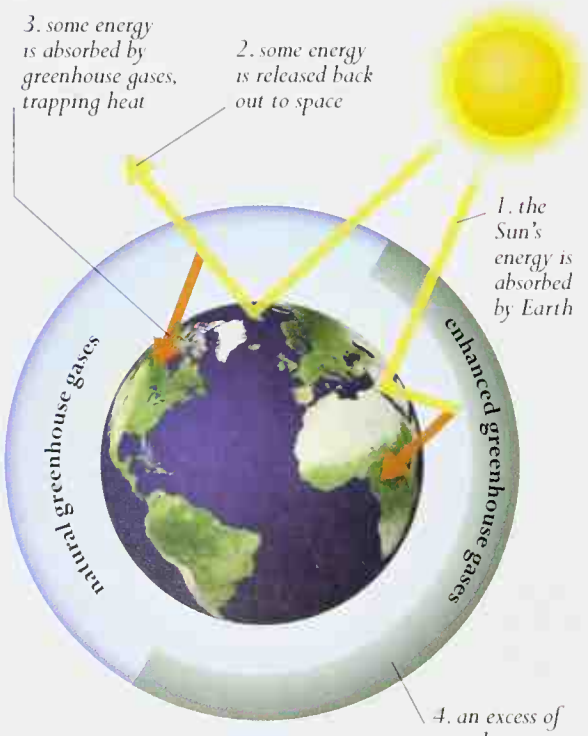
ENVIRONMENTAL CHANGE

Earth has a long history of climate change, which has ranged from glacial "ice ages" to warm "greenhouse" climates with widespread forestation and no ice in polar regions. Global warming is known to be linked to high levels of greenhouse gases in the atmosphere, such as carbon dioxide and methane, which trap incoming solar energy and raise the temperature of the oceans, land, and air. In the past, natural increases in atmospheric carbon dioxide have been balanced by the development of forests on land and lime-rich sediments in the seas, which eventually became coal and limestone and stored excess carbon dioxide effectively. Since the industrial revolution of the nineteenth century, human activity has released huge amounts of carbon dioxide and other greenhouse gases back into the atmosphere through the mining and burning of fossil fuels, the clearing of forests, and the rearing of cattle.

THE OCEANS

The health of Earth's oceans is vital to all life. Marine life depends upon the circulation of oceanic waters that contain enough oxygen and nutrients to support the food chain from plankton and shellfish to all the other animals that depend upon them for food. Fossil records show that when the oceanic environment deteriorated in the past, it led to extinctions of life. Today, human activities such as over-fishing and pollution are affecting the condition of the seas.

^ **OIL SLICK VICTIM**
Oil spills, which float on water, cause havoc when they reach land. They saturate coastlines and devastate coastal wildlife.


3. some energy is absorbed by greenhouse gases, trapping heat
2. some energy is released back out to space
1. the Sun's energy is absorbed by Earth
natural greenhouse gases
enhanced greenhouse gases
4. an excess of greenhouse gases traps too much of the Sun's energy, leading to a steep rise in Earth's temperature

^ **GREENHOUSE EFFECT**
An excess of greenhouse gases in the atmosphere creates a shield which prevents some of the Sun's energy from radiating back into space.

THE ATMOSPHERE

For thousands of years human activity has affected the atmosphere. Initially, it was restricted to the release of pollutants from domestic fires and forest clearance. In Roman times metal production released the first industrial pollutants into the atmosphere, leaving traces that can be seen in polar ice cores. Over the last 200 years, pollution by gases and particulates has risen steeply. This has produced acid rain and smog, and greenhouse gases that are linked to global warming and depletion of the ozone layer, which helps screen out harmful ultraviolet radiation.

THE LAND

Since settlements and agriculture became widespread 8,000 years ago, humans have had a growing impact upon Earth's landscapes. With worldwide population growth, many regions are now densely settled, with few or no untouched landscapes in between. Greater awareness of the impact of human activity on the environment is now leading to efforts to conserve natural habitats.

^ **POLAR ICE SHELF COLLAPSE**
Rising temperatures are leading to the collapse of the polar ice shelves. The release of such large volumes of water is raising sea levels, which in turn threatens coastlines.

AGRICULTURE
Natural landscapes are radically altered by intensive farming, such as the cultivation of rice in irrigated terraces throughout Asia. Such methods support big populations, but require large amounts of water.

EXTINCTION

The inability of many organisms to adapt to environmental change has led to a huge turnover of species throughout geological time. In fact, the vast majority of nature's species are now extinct. Only the fittest organisms survive, usually through gradual change, but sometimes by the sudden elimination of competitors. For example, when a huge asteroid hit Earth 65 million years ago, it set in motion a chain of events that led to the demise of many life forms, including the dinosaurs on land and the ammonites in the seas. But it also saw the survival of mammal species that led to the human race. More recently, the arrival of modern humans in different regions around the world has contributed to the extinction of particular species, such as the woolly mammoth in Europe and Asia (see far right). Today, as the human population expands, our actions are placing a growing number of species, such as the tiger, in imminent danger of extinction.

^ DECLINE OF THE CRESTED IBIS
Once widespread in Asia, hunting and habitat loss has restricted the crested ibis to a small wild population in China. Captive breeding has allowed it to be reintroduced to Japan.

< PERE DAVID'S DEER
Extinct in the wild, this east Asian deer has survived only in captive herds bred in England since 1900. Some captive offspring were reintroduced to nature reserves in China in the 1980s.

SCIENCE

MAMMOTHS NO MORE

Woolly mammoths were elephants that were adapted to the cold. They migrated across ice-age Europe and Asia in vast herds. Archaeological evidence such as cave paintings shows that they were actively hunted by humans around 30,000 years ago, which may have contributed to the extinction of most woolly mammoths by 11,000 years ago.

CAVE PAINTING, PECH-MERLE, FRANCE

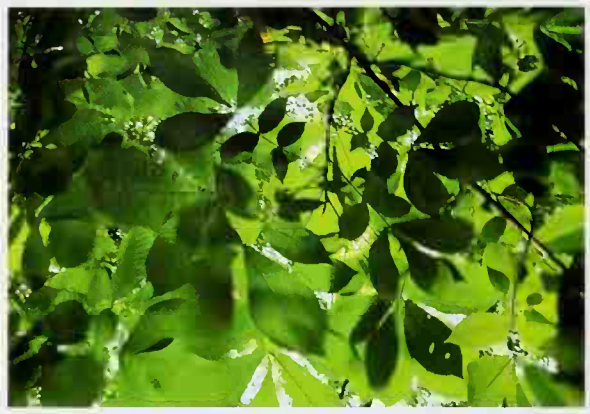
ORIGINS OF LIFE

The fossil record shows that life first appeared on Earth at least 3.8 billion years ago, and that all complex life has evolved from these first simple forms. Today, diverse life forms range from single-celled organisms to mammals with complex anatomies, such as giant whales.

WHAT IS LIFE?

There are several features that define life and distinguish an active, organic organism from inanimate, inorganic matter. These include an ability to take in and expend energy, to grow and change, to reproduce, to adapt to its environment, and—in more complex living organisms—to communicate.

The cell is the fundamental unit of life, capable of replicating itself and carrying out all living processes. Even the smallest independent organisms are made up of at least one cell, and almost every cell of every living organism has its own set of molecular instructions. Within each cell, the threadlike chromosomes carry hereditary information in the form of genes that are responsible for the particular characteristics of an organism. The set of instructions in a gene are mainly recorded in the form of a molecule called chromosomal deoxyribonucleic acid (DNA). The DNA of an organism carries information from one generation to another, allowing certain characteristics to be passed on from parent to offspring.

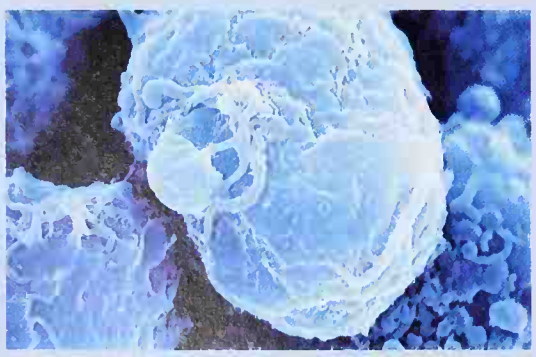


^ PHOTOSYNTHESIS
Plants use the pigment chlorophyll to capture light energy and convert water and carbon dioxide into sugars and oxygen. This benefits other life forms that feed on the plants and breathe in oxygen.

^ VITAL ENERGY
To sustain itself, life must obtain energy from the environment. Energy flows through a food chain from photosynthesis in plants to the animals that feed upon them and are, in turn, eaten by other animals.

SCIENCE
VIRUSES

Viruses are the most abundant biological entity on Earth, and they lie at the boundary between living and nonliving. While they have features in common with living organisms—they are made of genetic material and are protected by a protein coat—viruses are parasitic and can only reproduce within the living cells of other organisms. They are packets of chemicals that copy themselves, without truly being alive.



HIV-1 VIRUS

DIVISIONS OF LIFE

The huge array of life on Earth is divided into three domains or superkingdoms—Archaea, Bacteria, and Eukaryota –which encompass all life forms from plants and fungi to animals. The first two domains are formed of prokaryotes—primitive organisms that were probably the earliest form of life on Earth. The more advanced eukaryotes are distinguished from the prokaryotes by having a cell nucleus, which contains the cell's genetic material, DNA. Eukaryotes vary enormously in shape and size, ranging from single-celled organisms to complex, multicelled plants and animals.

< GROWTH
A capacity to grow and repair is a one of the key defining features of life. All organisms, from simple fungi to mammals, grow by means of increase in cell size and cell division.

EARLY LIFE

The very earliest forms of life evolved in the seas, and evidence of this comes from two main sources: living primitive organisms and the fossil record. The most primitive life forms today are single-celled prokaryotes, which can survive even in extreme temperatures and acidic conditions. Such microorganisms may be similar to those that first evolved in the extreme environments of early Earth.

Fossil evidence for early life on Earth consists of the remains of organims dating from around 3.8 billion years ago. They may have originated as microscopic prokaryotes that lived in the first oceans. Some of the most ancient records of life are layered, mound-shaped stromatolites (see right).

FLOURISHING LIFE
Ever since life first appeared on Earth, it has thrived in the sea, evolving into the biodiversity hotspots of modern, sunlit reefs, second only to rain forests for the variety and density of life they sustain.

From the first appearance of simple life, it took another 2.5 billion years before complex life forms appeared. The fossil of a microscopic and multicelled red algae called *Bangiomorpha* provides the first evidence of the existence of specialized cells. These cells evolved for sexual reproduction, and also for the development of a holdfast to attach the algae to the sea floor.

< STROMATOLITES
For billions of years these layered structures have built up in shallow tropical seas by alternating layers of sediment and sheets of microorganisms, including cyanobacteria (blue-green algae).

By about 750–550 million years ago, the first sponges with colonies of cells had evolved, growing to 4 in (10 cm) high with spiny skeletons for support and protection. By the beginning of the Cambrian period, 545 million years ago, numerous multicelled marine organisms had evolved, including burrowing worms and a variety of small, shelled mollusks, whose bodies had muscle tissues and organs such as gills for respiration. Around 510 million years ago, the first vertebrates appeared, with an internal skeletal support for the body. By late Devonian times, around 380 million years ago, vertebrates had begun to emerge from the seas onto land.

^ BURGESS SHALE
The fossils of the Burgess Shale in Canada show that marine life diversified rapidly in Cambrian times, from sponges and arthropods to vertebrates.

WIWAXIA >
Found at the Burgess Shale, *Wiwaxia* was a 2-in-long (5 cm), mollusklike seabed crawler with spines and scales, and a soft undersurface.

EVOLUTION AND DIVERSITY

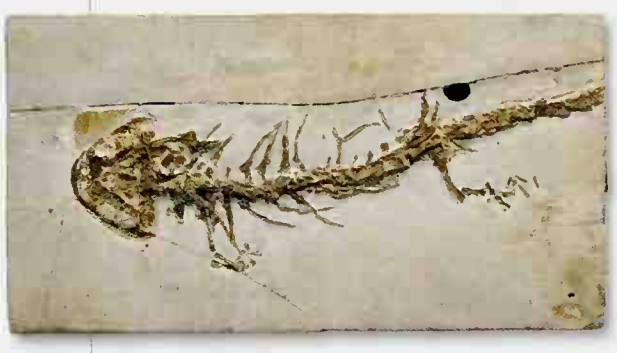
Until the nineteenth century, when a number of theories were proposed, it was a matter of speculation as to how such remarkably diverse life forms had developed on Earth. Today, the theory of evolution and diversification, alongside geological evidence for changes in the distribution of continents, give a fascinating insight into the ever-changing life on our planet.

CHANGE OVER TIME

All living things have the capacity to change and adapt to their surroundings. Tiny, subtle changes that are passed down from generation to generation are hard to see, but over time—sometimes thousands or even millions of years—they can alter the way a certain species looks or behaves. This process is known as evolution.

The study of fossils to unravel the history of life was in its early stages in Charles Darwin's day (see p.25), and since then a vast amount of information supporting the theory of evolution has emerged. We now know that life evolved in the oceans some 3.8 billion years ago, and that it was from these early simple life forms that all current life on Earth evolved—including plants, fungi, and animals.

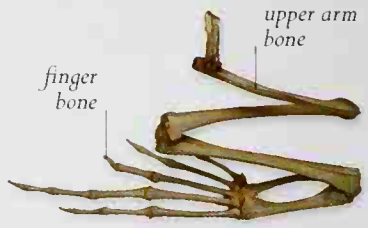
As life forms became more complex and moved from sea to land, the first forests and land-living invertebrates evolved. The Mesozoic era, around 250 millions years ago, with its successions of evolving plants and animals, produced the dominant dinosaur reptiles and their bird descendents. These reptiles were largely replaced by mammals both in the seas and on land in Cenozoic times—from 65 million years ago to the present—when flowering plants and their pollinating insects also became abundant and diverse.



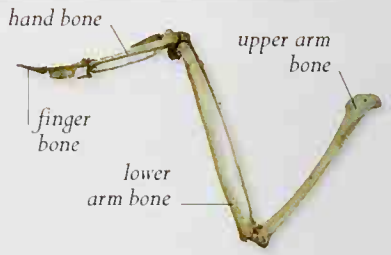
< GIANT SALAMANDER
This extremely rare fossil skeleton of an *Andrias* (giant salamander) was mistaken for a human victim of the biblical Flood until French anatomist Georges Cuvier identified it as an amphibian in 1812.

EVIDENCE OF EVOLUTION
Comparison of the anatomy of vertebrate limb bones from different species show that, despite different appearances and functions, they derive from the same basic developmental plan and the same genes.

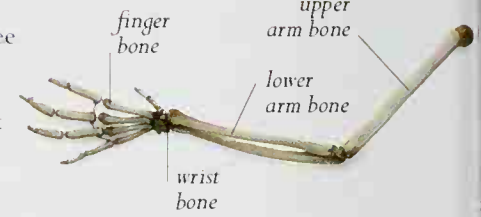
FROG
The frog's leg, arm, and finger bones are modified for swimming. Large muscles enable it to jump powerfully—essential for catching prey and escaping from predators.



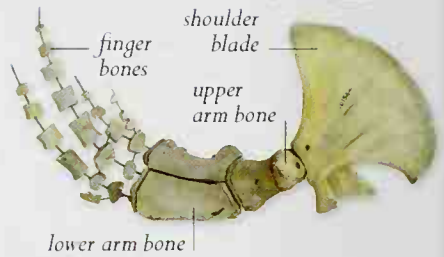
OWL
The wing of a bird is powered by flight muscles attached to the upper arm and bones of the wrist, with greatly modified and extended fingers.



CHIMPANZEE
The arm of a chimpanzee is anatomically very similar to our own, but has slightly different proportions, with elongated fingers and a short thumb.

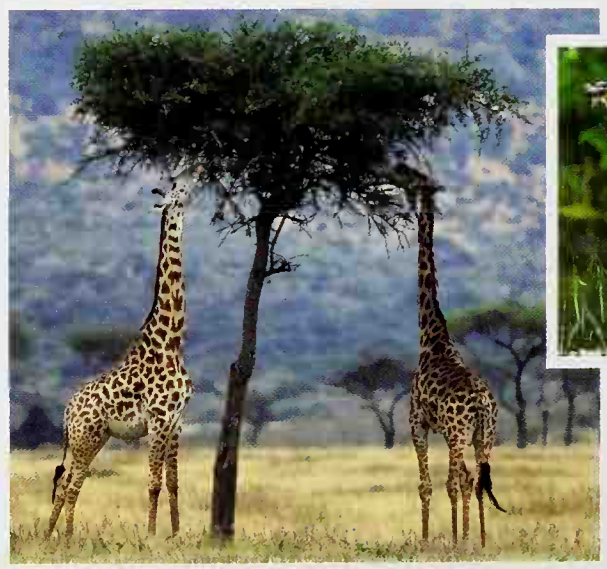


DOLPHIN
The arm bones of whales and dolphins form a flipper—with shortened, flattened, and strengthened arm bones and greatly lengthened second and third fingers.



LAMARCK LEADS THE WAY

The eighteenth-century French biologist Jean-Baptiste Lamarck developed the first comprehensive evolutionary theory that higher forms of life had "evolved" from simpler organisms. Based on his extensive research of invertebrates in particular, Lamarck argued that necessary characteristics could be acquired during an organism's lifetime—through the desire to gain food, shelter, and mates—and those not needed could be lost, with the resulting transformation passed on to its offspring. Although modern genetics disproves this theory of "soft inheritance," Lamarck's concepts were an important starting point, and were developed further by the Scottish anatomist Robert Grant, who tutored Charles Darwin in Edinburgh. Darwin himself did not entirely rule out a Lamarckian mechanism, which he thought might be supplementary to natural selection.



< ^ INNER STRIVING
Lamarck believed that evolution worked through a process of "inner striving." Thus the giraffe developed a long neck to reach the leaves of trees, and the heron grew long legs in order to wade.

^ GALAPAGOS FINCHES
On his voyages, Darwin collected many different specimens of Galapagos finches which he believed may have descended from a common ancestor.

DARWIN AND WALLACE

In the mid nineteenth century, British naturalists Charles Darwin and Alfred Russel Wallace independently came up with the theory of evolution by natural selection. They both had experience of fieldwork in the tropics—an environment boasting high biodiversity, competition for resources, and marked differences in the organisms living in separate areas. They both wondered how and why such natural phenomena had arisen. On his travels Wallace collected specimens for study and sale, and it was in the Malay Archipelago that he formulated his explanations for the geographical distribution of organisms—biogeography—and realized the role of natural selection in evolution. Meanwhile, Darwin's five-year voyage on *HMS Beagle* around the Southern Hemisphere as a gentleman naturalist provided him with much material to formulate his own theory of evolution. In 1858, Wallace and Darwin produced a joint publication on natural selection, and the following year Darwin expanded the theory to produce his famous and influential book, *On the Origin of Species*.

butterfly wing

specimen box

^ COLLECTION BOX
Both Darwin and Wallace were fascinated by insect diversity, especially as found in the tropics, and were keen collectors.

Cynognathus
reptile fossils from the Triassic Period

Lystrosaurus
reptile fossils from the Triassic

Mesosaurus
reptile fossils from the Permian Period

Glossopteris
plant fossils from the Permian Period

AFRICA
INDIA
SOUTH AMERICA
AUSTRALIA
ANTARCTICA

< BIOGEOGRAPHY
The distribution of certain reptile and plant fossils across the southern continents shows that they were once joined as a supercontinent, called Gondwana.

^ FIRST BIRD
The discovery of the fossil *Archaeopteryx* in 1861 revealed characteristics that provided an evolutionary link between two major groups: reptiles and birds.

EVOLUTION IN PROGRESS

Darwin and Wallace proposed the theory of natural selection, but it was the discovery of the gene that gave scientists the mechanism by which selection takes place. Understanding the gene has since become the key to understanding evolution.

NATURAL SELECTION

A key evolutionary mechanism, natural selection favours the survival of the fittest. In other words, individuals that possess characteristics best adapted to their current environment have a better chance of surviving to reproduce and pass on those favorable traits to another generation. Natural genetic variation within populations produces differences such as size, shape, and color, and some of these may help promote survival. For instance, a particular body coloration may provide a camouflage that better hides the animal from predators than other colors would. If this leads to the survival of that animal and to its reproduction, that same improved coloration will be passed on to some of its offspring. If the environment were to change over time, a different coloration might be more beneficial, and so natural selection will ensure another change. A split into two populations may even occur after a geographic rift, with each new population becoming adapted to slightly different conditions. Eventually, this may lead to one species becoming two, in a process known as speciation.

^ INDIVIDUAL VARIATION
Litters of domestic cats commonly include individuals with varied coloration, especially where the parents' colors differ.

< v SEXUAL DIMORPHISM
In many species, there are marked differences between males and females. Male frigatebirds use their inflatable throat pouch to attract the females.

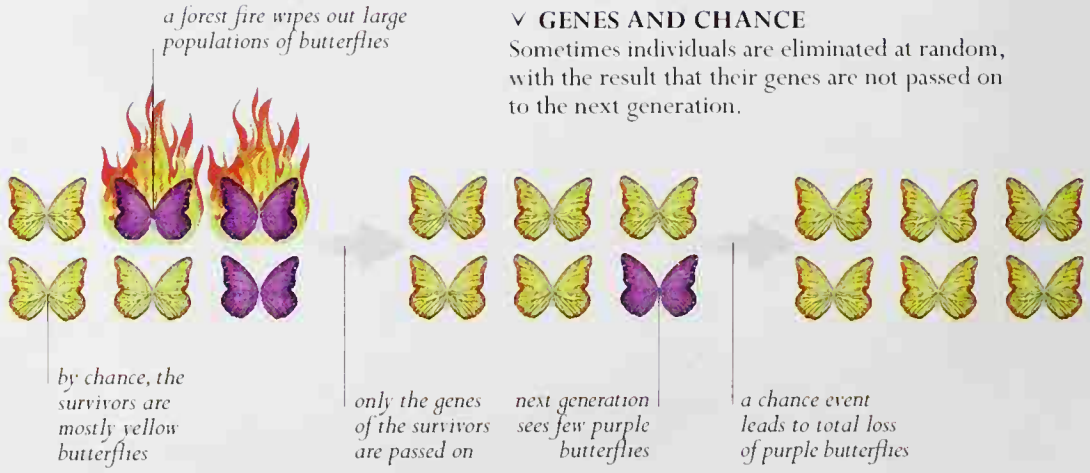
SCIENCE

CREATIONISM: BELIEF VERSUS SCIENCE

Most of the world's religions provide a theory of creation, which gives an explanation for the formation of Earth and life. Many of these creation stories originated long before scientific data and theories were available to offer alternative explanations and understanding. Some believers in the Western Judeo-Christian tradition maintain that the complexity of "design" in many organisms implies that there must have been a "designer"—God—behind their creation, and for this reason they dispute the theory of evolution.

GENES AND INHERITANCE

Particular traits pass from parents to offspring through the transmission of genetic material. Genes preserve, encoded in their DNA, all the information necessary for the replication of a cell's structure and its maintenance. Genes are therefore the basic units of heredity. Individual chromosomes—the thread-like part of a cell—hold thousands of genes on long strands of DNA. During sexual reproduction, the fusion of sperm and egg cells produces two complete sets of gene-bearing chromosomes: one copy from the father and one from the mother.


a forest fire wipes out large populations of butterflies
by chance, the survivors are mostly yellow butterflies
only the genes of the survivors are passed on
next generation sees few purple butterflies
a chance event leads to total loss of purple butterflies

v GENES AND CHANCE
Sometimes individuals are eliminated at random, with the result that their genes are not passed on to the next generation.

ADAPTING TO EXTREMES
The lesser flamingo has evolved to occupy a very specialized niche: to feed on algae in extremely alkaline African lakes. In the absence of competitors, it can thrive there in huge numbers.

ISLAND EVOLUTION

Isolated islands provide natural laboratories for unusually fast evolution, with intense competition for limited resources leading to rapid speciation. In 1835, Darwin's visit to the Galapagos Islands allowed him to collect many bird specimens, particularly finches. He noted slight variations between the specimens from island to island. He also heard about the differences between the giant tortoises on separate islands, and subsequent visits to other Pacific islands made him wonder about the possibility of new species evolving from a common ancestor. The ornithologist John Gould was able to identify Darwin's finches as a new group of 12 separate species, rather than just varieties of the same species. This persuaded Darwin that species could change under certain conditions such as island isolation. Island wildlife continues to be an important research area for modern evolutionary biologists.

< **FLIGHTLESS BIRDS**
Many flightless birds, such as the kiwi, evolved on the islands of New Zealand, which lacked serious predators until humans arrived.

ARTIFICIAL SELECTION

Over millennia, humans have domesticated many different kinds of animals and plants, from dogs and cattle to fruit trees and cereal crops. Before the discovery of the gene, this was achieved simply by selectively interbreeding organisms bearing the desired characteristics—such as the ability to run fast or produce more succulent fruit—over many generations, until the selected traits became dominant. Today, biotechnology achieves the same result much faster by directly manipulating genes, both to enhance beneficial traits and to remove problematic ones.

^ **GENETIC MODIFICATION**
Alteration to the genetic makeup of organisms can remove undesired characteristics and add more useful ones, such as resistance to disease.

^ **CLONING**
Genetically identical individuals can be created by the transfer of a nucleus—with its genetic information—from an adult cell into a host egg cell.

CLASSIFICATION

Global diversity is estimated to range from two to 100 million species. Only 1.4 million have been described, but many new species are added each year. All are named and classified using a system devised over 250 years ago.

"DOG ROSE" >
Known as the dog rose, wild briar, witches' briar, dogberry, eglantine gall, and the hip tree, this plant has only one Latin name, *Rosa canina*, which identifies it for everyone everywhere.

< "PUMA"
The puma is also known as the cougar or mountain lion. Its Latin name, *Puma concolor*, alludes to its uniform color.

For centuries people have studied the natural world. Initially they were limited to what they could find locally and to reports from travelers because it was impossible to preserve and send specimens any distance. Later, as travel became easier, explorers were paid to collect plants and animals and ship's artists would draw them. By the early 1600s natural history collections in Europe were substantial, and many specimens had been described, but there was no formal arrangement that made these specimens or accounts of them easily accessible.

The aim of the early taxonomists, or scientists who describe and classify species, was simple—to organize living things so that they reflected God's plan of creation. Between 1660 and 1713 John Ray published works on plants, insects, birds, fish, and mammals, forming his groups on the basis of morphological (structural) similarities. The science of morphology, along with other criteria such as behavior and modern genetics, forms the basis of classification today. In 1758 the tenth edition of *Systema Naturae* was published. It was written by the Swedish botanist Carolus Linnaeus. He and his friend Peter Artedi had decided to divide the natural world between them and classify everything in it, fitting the 7,300 described species into the same hierarchical framework. Although Artedi died before his book was finished, Linnaeus completed the work and published it along with his own.

LATIN NAMES

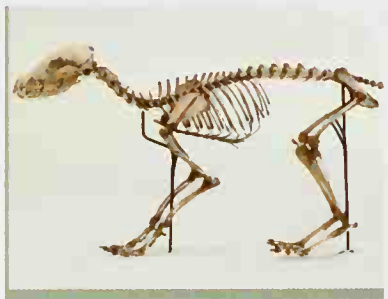
All living things now have a unique Latin name—such as *Panthera leo* for the lion—which is made up of the genus name, starting with a capital letter, and a descriptive species name. Linnaeus devised this binomial method for identifying different organisms to replace the arbitrary descriptions that existed previously. The new method put an end to confusion caused by the same name being given to several species, or to single species being know by several names.

Within a species, distinct subspecies can sometimes be recognized in different locations. In the 1800s Elliot Coues and Walter Rothschild adopted a trinomial Latin system to accommodate them. This convention for naming species and subspecies is still used today.

TRADITIONAL CLASSIFICATION

DOMAIN
Eukaryota
The latest taxonomic unit to be created is the domain. It is based on whether organisms possess cells with a nucleus (eukaryotes: protoctists, plants, fungi, and animals) or not (prokaryotes: Archaea and Bacteria).

KINGDOM
Animalia
In recent years, the traditional kingdoms of plants and animals have been further subdivided. Kingdom Animalia now includes only multicellular organisms that must eat other species in order to survive.



PHYLUM
Chordata
A phylum (known as a division in plants) is a major subdivision of a kingdom and is made up of one or more classes that share certain features. Members of the phylum Chordata have a notochord—the precursor of the backbone.

CLASS
Mammalia
Introduced by Carl Linnaeus, a class contains one or more orders. Class Mammalia includes only animals that are warm-blooded, have fur, a single jaw bone, and that suckle their young on milk.

> CONTRIBUTING TO CLASSIFICATION
Over the years many scientists have attempted to organize the natural world, combining earlier ideas with new research, culminating in the traditional system of classification shown above and the use of bi- and trinomial Latin names. Some scientists were particularly influential, making significant contributions to taxonomy.

ANIMALS AND PLANTS

Aristotle was the first person to classify living things, and he introduced the term *genos* (meaning race, stock, kin)—genus in Latin. He separated animals into those with blood and those without, not realizing blood need not be red. This division is very close to the modern classification of vertebrates and invertebrates.

ARISTOTLE, 384 BCE–322 BCE

ORDER FROM CHAOS

John Ray classified organisms based on their overall morphology rather than just a part of it. In doing so he could establish relationships between species more easily and organize them into groups more effectively. He also divided the flowering plants into two major groups of orders—monocotyledons and dicotyledons.

JOHN RAY, 1627–1705

CLASSIFYING INSECTS
About 17,500 species of butterflies have now been described. In order to identify them or recognize new species, museums hold vast reference collections, like this one, for comparative purposes.

ORDER
Carnivora
Orders are the next level down in Linnaeus's hierarchy, and contain one or more families. The Carnivora have modified cheek teeth (carnassials) and large canine teeth specialized for biting and shearing.

FAMILY
Canidae
A subdivision of an order, a family is made up of genera and the species within them. The family Canidae has 35 living species, all with nonretractile claws and two fused wrist bones. All but one species have long, bushy tails.

GENUS
Vulpes
A term first used by Aristotle in Ancient Greece, a genus identifies subdivisions of a family. *Vulpes* is a genus within the family Canidae. All foxes have large, triangular ears and a long, narrow, pointed snout.

SPECIES
Vulpes vulpes
The basic unit of taxonomy, species are populations of similar animals that breed only with one another. *Vulpes vulpes*, known for its bright red fur, breeds only with other European red foxes.

ANIMAL, VEGETABLE, OR MINERAL

Linnaeus divided the natural world into three kingdoms—animals, plants, and minerals. He then devised a hierarchical system of classification based on class, order, family, genus, and species, and established the convention of giving species binomial Latin names.

CARL LINNAEUS, 1707–1778

A NEW KINGDOM

Historically organisms were classed as being either animals or plants, but in 1866 Ernst Haeckel argued that microscopic organisms formed a separate group, which he called Protista (now Protoctista). There were now three kingdoms of life: Animalia, Plantae, and Protista.

ERNST HAECKEL, 1834–1919

INTRODUCING THE ARCHAEA

Recognized by Carl Woese and George Fox in 1977, the Archaea are microscopic organisms that live in very extreme environments. Initially grouped with the Bacteria, their DNA turned out to be so unique that a new three-domain taxonomic system was introduced.

CARL WOESE, BORN 1928

ANIMAL GENEALOGY

In the 1950s a revolutionary new way of classifying organisms was proposed. Called phylogenetics, it allowed taxonomists to investigate evolutionary relationships between species by placing them in hierarchical groups called clades.

Phylogenetics, also known as cladistics, is based on the work of entomologist Willi Hennig (1913–1976). He assumed that organisms with the same morphological characters must be more closely related to each other than to those that lacked them. Therefore, these organisms must also share the same evolutionary history and have a more recent ancestor in common. Like the traditional taxonomy of Linnaeus, this method of classifying organisms is hierarchical, but due to the volume of data involved, computers are used to generate the family trees, known as cladograms.

For a morphological feature to be useful in cladistic analysis, it must have altered in some way from the so-called "primitive" ancestral condition to a "derived" one. For example, the legs and paws of most carnivores are considered primitive in the cladogram on the opposite page, compared to the derived condition of flippers in the seals, fur seals and sea lions, and walruses. This derived character, called a synapomorphy, is useful because it is shared between at least two taxonomic groups, suggesting they are more closely related to each other than to groups without flippers. Characters that are unique to one group are useful for recognition purposes but say nothing about relationships. So cladistic analysis is based entirely on the identification of synapomorphic characters.

UNDERSTANDING ANCESTRY

The more derived characters organisms have in common, the closer their relationship is assumed to be. For instance, brothers and sisters look more alike than other children—they may have the same eyes, the same chin, and so on. This is because in terms of common ancestry they have the same parents but are only distantly related to other people.

Cladistics is now most commonly based on genetics—except in the study of fossils—and has exposed some unexpected shared ancestry. For example, a genetic cladogram surprisingly revealed that the whale is most closely linked to the land-dwelling hippopotamus—a relationship that Linnaeus would certainly not have expected.

SCIENCE
OUTGROUPS

The first step in doing cladistic analysis of a group is to choose a closely related but more primitive species (the outgroup) for comparison. This allows derived characters to be distinguished from primitive ones. For example, to work out a phylogenetic tree of birds, a crocodile might be chosen as the outgroup, as both birds and crocodiles belong to the clade Archosauria.

A PRIMITIVE BIRD RELATIVE

CLOSE RELATIONS

The giraffes and kudus are both even-toed ungulates, so are more closely related to each other than to the odd-toed zebras. As fur-bearing mammals, all three are more closely related to each other than to the feathered birds flying around them.

LOOKING AT CLADOGRAMS

To do a cladistic analyisis, the different groups of organisms are scored on a set of characters that are either primitive or derived. Their distribution is not always as straightforward as is shown in the diagrams below. Often the resulting cladogram can be constructed in a number of different ways and taxonomists have to choose between them. To do this they adopt the principle of parsimony—they choose the cladogram involving the least number of steps or character transformations to explain the observed relationships between the groups.

< MILKY DIET
All mammals possess mammary glands. Unique to the class Mammalia, this feature is synapomorphic at this taxonomic level. To find further familial relationships within the class, characters that are synapomorphic at familial level are used.

CHARACTER	CANID	BEAR	SEAL	FUR SEAL & SEA LION	WALRUS
Feeding young on milk	1	1	1	1	1
Short tail	0	1	1	1	1
Forelimbs modified into flippers	0	0	1	1	1
Very flexible spine	0	0	1	1	1
Hind limbs turn forwards under body	0	0	0	1	1
Presence of tusks	0	0	0	0	1

< CHARACTER SET
Most modern cladograms are based on genetics using DNA codes. The codes that were used to generate the cladogram below have been replaced with more familiar morphological descriptions in this character set, left. One character, feeding young on milk, is shared by all the groups shown; some characters are found in only some of the groups; and one character, the presence of tusks, is unique to the walrus.

v CLADOGRAM
In this cladogram the canids are considered the most primitive group, known as the outgroup, and the walrus is the most derived. All characters on the cladogram are shared by the groups to the right of each number—for example, a short tail is shared by the bears, seals, fur seals and sealions, and the walrus.

KEY

0	primitive character
1	derived character

CANIDS

BEARS

SEALS

FUR SEALS AND SEA LIONS

WALRUS

the outgroup does not share character 1

two characters differentiate the seals, fur seals and sea lions, and walruses from the bears

only the fur seals and sea lions, and the walruses share character 4

walrus is the most derived genus in this cladogram

1

SHORT TAIL
Bears, seals, fur seals and sea lions, and the walrus all have short tails (character 1). Canids, however, display the primitive condition and have long, bushy tails. Character 1 is therefore a synapomorphic character shared by all the carnivore families shown except the canids.

2

FLIPPERS
Among carnivores, the modified limbs of seals, fur seals and sea lions, and the walrus are unique. Character 2 (forelimbs modified into flippers) is therefore synapomorphic at this level, suggesting these three groups are more closely related to one another than to the bears.

3

FLEXIBLE SPINE
Character 3 (flexible spine) operates at the same level as character 2, further supporting the relationship indicated by possession of flippers. The more synapomorphic characters that appear at a particular level, the more convincing the suggested relationship becomes.

4

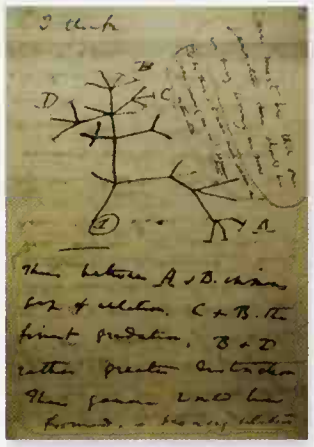
SUPPORTING LIMBS
In both the fur seals and sea lions and the walrus, the pelvic girdle can be rotated to allow the hind limbs to aid locomotion on land. This suggests they share a more recent common ancestor with each other than they do with the seals, which are far less mobile when out of water.

5

TUSKS
This is a unique character (autapomorphy) of the walrus that reveals nothing about its relationship to other mammal families. The same is true of the character "feed young on milk"—present in all the groups, it provides no clues as to how they interrelate, so it is not plotted on the cladogram.

TREE OF LIFE

Using a branching tree as a way of showing the diversity of life was first suggested by the German naturalist Peter Pallas in 1766. Since then many such trees have been constructed. Initially treelike, complete with bark and leaves, they later became more diagrammatic, and took account of evolutionary theories. Modern, computer-generated trees of life present many different ideas of how living organisms are related.



DARWIN'S FIRST TREE

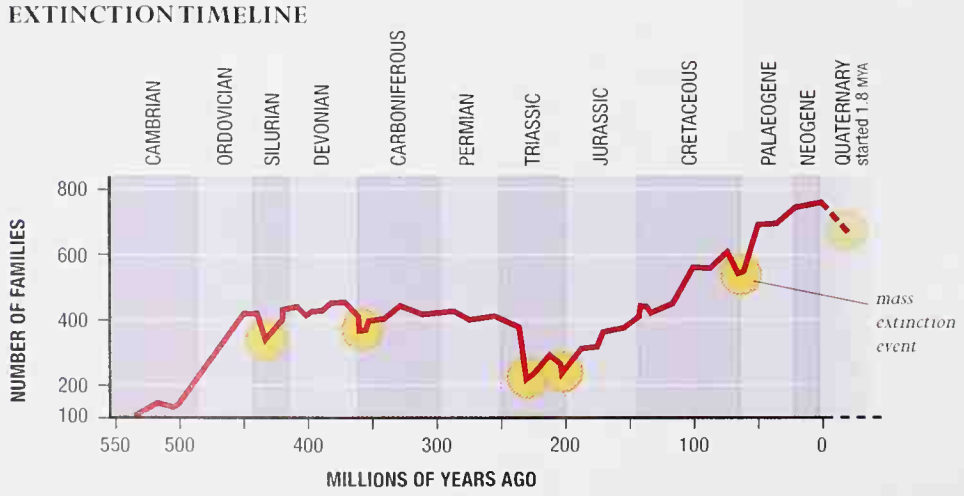
The first person to produce a tree of life that reflected the concept of evolution was Charles Darwin. He sketched the first of his ten evolutionary trees of life in 1837. It was a simple branching diagram, which he developed further before publishing it in the *Origin of Species* in 1859. The lettered branches show how he thought his theory might work—the more branch points separating an organism from its ancestor (numbered 1), the more different the organism will be. In 1879, Ernst Haeckel took the idea further, with a tree that showed animals evolving from single-celled organisms. Today DNA and protein analyses as well as morphology are used to construct evolutionary trees and establish the genetic relationships between organisms. Vast data sets require computers to generate the trees, which are continually refined as new species and information are discovered.

Trees of life inevitably place most emphasis on vertebrate groups within chordates because their relationships are well known. The many microscopic prokaryotes (archaea and bacteria) and protists (those eukaryotes not classified as plants, animals or fungi) are often under-represented because their relationships are more problematic. As more is learned about microscopic life, the trees change.

MASS EXTINCTIONS

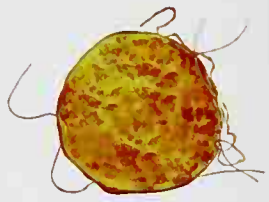
Mapping all life forms that have ever existed on a tree is difficult because, over time, more than 95 percent of all species have become extinct. A mass extinction occurs when a large number of species dies off at the same time. This has happened five times in the past. The best-known extinction, which wiped out the dinosaurs, occurred at the end of the Cretaceous Period; it is thought to have been caused by a meteor impact combined with volcanic activity. Because habitats are rapidly destroyed by human activity, it is likely that there will be another extinction event in the future.

EXTINCTION TIMELINE



READING THE TREE

This diagram shows how life evolved from simple organisms, such as the Archaea—which appeared about 3.4 billion years ago—to complex life forms, such as animals, which appeared 540 million years ago. It also shows the diversity of the vertebrates (see pp. 34–5), which have a disproportionate representation here. The circles indicate points where two or more groups of organisms have branched from a common ancestor at about the same time. Only extant species are shown.



LIFE BEGINS

ARCHAEA

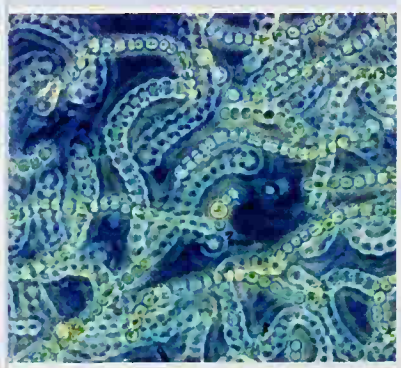
PROKARYOTES

BACTERIA

STRUCTURE OF LIFE

All forms of life are either prokaryotic or eukaryotic. Prokaryotes lack a cell nucleus and are usually unicellular. Eukaryotic organisms tend to be multicellular; each cell contains a nucleus, within which DNA is stored. This table shows which of these two groups the six kingdoms belong to. Despite appearances, most organisms are prokaryotic. The Archaea and Bacteria are the largest groups—although only about 10,000 species have been described, estimates exceed 10 million species. Among eukaryotes, the phyla that make up the protists and invertebrates are far more numerous in terms of species than vertebrate groups.

PROKARYOTES	EUKARYOTES
ARCHAEA	PROTISTS
BACTERIA	PLANTS
	LIVERWORTS
	MOSSES
	FERNS AND RELATIVES
	CYCADS, GINKGOS, GNETOPHYTES
	FLOWERING PLANTS
	FUNGI
	MUSHROOMS
	SAC FUNGI
	LICHENS
	ANIMALS
	INVERTEBRATES
	CHORDATES

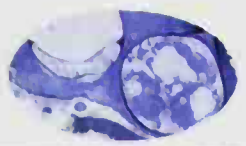


CYANOBACTERIA

SAC FUNGI, YEASTS

GLOMEROMYCETES

CHYTRIDIOMYCETES

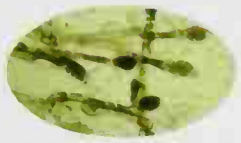


NEOCALLIMASTIGOMYCETES

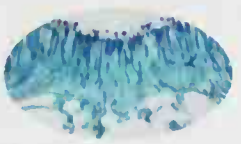
LICHENS

Lichens are classified according to the fungal half of the partnership

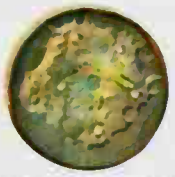
MUSHROOMS, RUSTS, & SMUTS



BLASTOCLADIOMYCETES

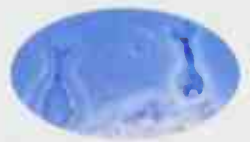


ZYGOMYCETES



AMOEBOZOANS

FUNGI



CHOANOFLAGELLATES

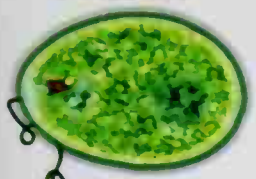
ANIMALS »

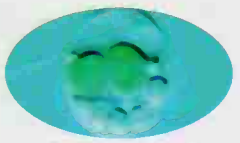
EUKARYOTES

EXCAVATES

KINETOPLASTIDS

EUGLENIDS





GLAUCOPHYTES

FERNS & RELATIVES

EUDICOTS

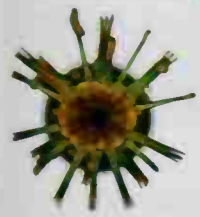
MAGNOLIIDS

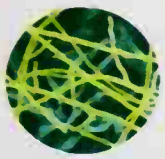
LIVERWORTS

RHIZARIANS

BROWN ALGAE

RADIOLARIANS





WATER MOLDS

PLANTS

GREEN ALGAE

MOSSES

FLOWERING PLANTS

CYCADS, GINKGOS, GNETOPHYTES

MONOCOTS

FORAMINIFERANS

HETEROKONTS

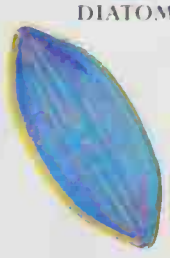
RED ALGAE

CONIFERS

CERCOZOANS

GYMNOCHLORA STELLATA

DIATOMS



ALVEOLATES

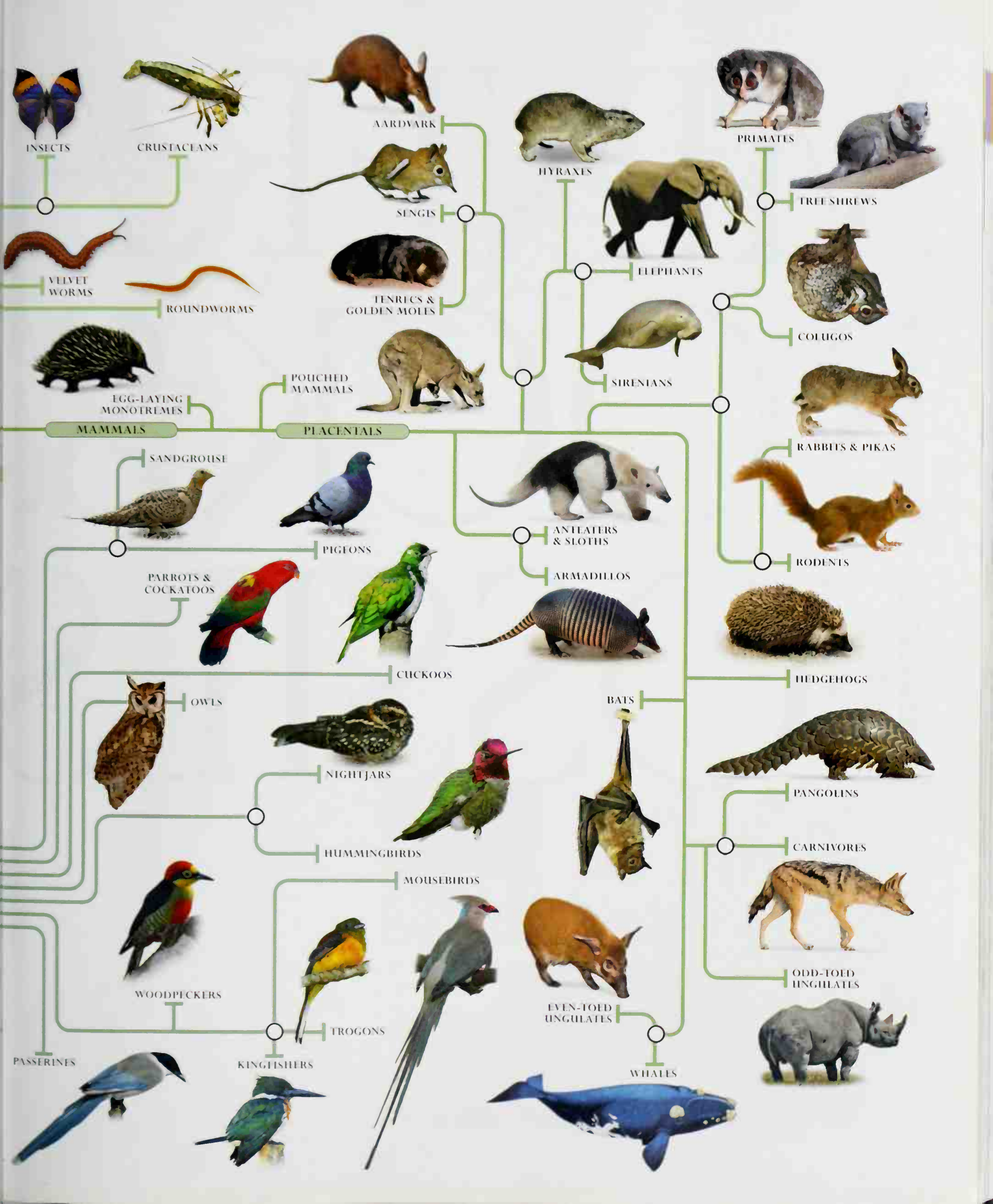
APICOMPLEXANS

DINOFLAGELLATES

CILIATES

BASAL FAMILIES

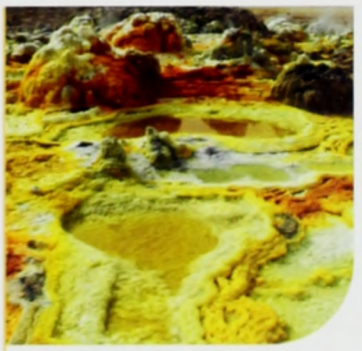
APLACOPHORANS
CHITONS
GASTROPODS
CEPHALOPODS
BIVALVES
TUSKSHELLS
SEA SPIDERS
ARACHNIDS
HORSESHOE CRAB
MILLIPEDES & CENTIPEDES
RIBBON WORMS
MOLLUSKS
ARTHROPODS
SEGMENTED WORMS
FLATWORMS
WATER BEARS
LAMPSHELLS
LOBE-FINNED FISHES
BRYOZOANS
TUNICATES
HAGFISHES
CARTILAGINOUS FISHES
ANIMALS
CHORDATES
VERTEBRATES
AMPHIBIANS
REPTILES
SPONGES
ECHINODERMS
LANCELETS
JAWLESS FISHES
RAY-FINNED FISHES
TURTLES & TORTOISES
CNIDARIANS
SNAKES
TUATARAS
CROCODILIANS
CAECILIANS
LIZARDS & AMPHISBAENIANS
BIRDS
FROGS & TOADS
TINAMOUS
SALAMANDERS & NEWTS
RATITES
GAMEBIRDS
WATERFOWL
WADERS
CRANES & RAILS
BIRDS OF PREY
PELICANS
STORKS
FLAMINGOS
GREBES
ALBATROSSES
LOONS
PENGUINS


INSECTS
CRUSTACEANS
AARDVARK
HYRAXES
PRIMATES
SENGIS
TREE SHREWS
ELEPHANTS
VELVET WORMS
ROUNDWORMS
TENRECS & GOLDEN MOLES
COLUGOS
EGG-LAYING MONOTREMES
POUCHED MAMMALS
SIRENIANS
MAMMALS
PLACENTALS
RABBITS & PIKAS
SANDGROUSE
ANTEATERS & SLOTHS
RODENTS
PIGEONS
PARROTS & COCKATOOS
ARMADILLOS
HEDGEHOGS
CUCKOOS
OWLS
BATS
NIGHTJARS
PANGOLINS
HUMMINGBIRDS
CARNIVORES
MOUSEBIRDS
WOODPECKERS
ODD-TOED UNGULATES
EVEN-TOED UNGULATES
TROGONS
PASSERINES
KINGFISHERS
WHALES

MINERA
ROCKS,
FOSSILS

L S, &

Life on Earth is shaped by the rocks that lie beneath our feet. Made of different combinations of minerals, they have a far-reaching influence on the landscape, on vegetation, and on the soil. Preserved within these rocks, fossils form a highly detailed record of life in the distant past, showing the path that evolution has followed over hundreds of millions of years.



» 38

MINERALS

The building blocks of rocks, minerals typically have a crystalline structure. Several thousand exist in Earth's crust, but fewer than 50 minerals are common and widespread.

» 62

ROCKS

Classified according to how they formed, rocks are constantly broken down and reformed. The oldest rocks date back 3.8 billion years, when Earth's crust first solidified.

» 74

FOSSILS

Most fossils preserve hard remains, such as teeth and bones. They can also include traces such as footprints, and carbon impressions in rock, which reveal the past existence of living things.

MINERALS

Minerals are the materials from which rocks are made. More than 4,000 different kinds exist, each one a single chemical substance found naturally on Earth. Most minerals are hard and crystalline, and, while some are extremely abundant, others—including diamond—are very rare, and highly prized.

Copper often appears in a dendritic form, branching like a tree. It is a very important economic mineral.

Malachite can be botryoidal, with small, rounded shapes, or massive, with no definite shape.

Crocoite, which is lead chromate, frequently occurs as slender, elongated prismatic crystals.

Minerals are of great economic significance. They provide us with countless useful materials, from metals to industrial catalysts, and they also include objects of great intrinsic beauty, particularly when cut and polished as gems. But on an even broader scale, minerals are essential for life itself. In soil and in water, soluble types release a steady stream of chemical nutrients that plants and other organisms need to grow. Without them, the world's ecosystems would no longer operate.

Minerals are classified according to their chemistry. A few, such as gold, silver, and sulfur, can exist in a native state, meaning that they contain a pure chemical element and nothing else. All other minerals are chemical compounds. Quartz, for example, contains two elements—silicon and oxygen—which are bound together very tightly, giving quartz its exceptional hardness and strength. Quartz belongs to the silicate group of minerals, which makes up about 75 percent of the Earth's crust. Other common mineral groups include halides, such as halite, or common salt, and phosphates and carbonates. These last two groups are particularly important to animals, which use phosphate and carbonate minerals—for example, calcite—to construct hard body parts, such as teeth, bones, and shells.

IDENTIFYING MINERALS

With experience, many minerals can be identified by their appearance and texture alone. Important clues include their color, their luster—the way light reflects from their surface—and above all, their habit, or crystal form. Crystals are grouped into six systems according to their symmetry (see panel, below). In addition, the crystals themselves can be arranged in different ways: many are parallel, but they can be dendritic (branching), or even botryoidal (like a bunch of grapes).

Minerals also differ in density, or specific gravity (SG)—measured by comparing the weight of a mineral to that of an equal volume of water—and in their hardness (H). On the 10-point Mohs scale, which measures hardness, talc is rated 1, whereas diamond, the hardest mineral, is rated 10. A fingernail (hardness 2), copper coin (3.5), and steel knife blade (6) all make useful benchmarks for testing hardness. Surprisingly, size is a less useful clue. Gypsum crystals, for example, are usually less than ⅜ in (1 cm) long, but the largest specimens ever discovered are the size of a two-story house.

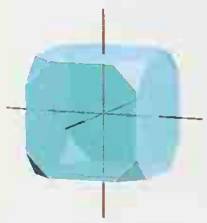
VOLCANIC MINERALS >
The ground at Dallol in Ethiopia's Danakil Desert is pockmarked by volcanic vents and covered in sulfur, a native element.

DEBATE

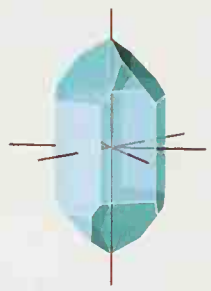
MINERALS OR NOT?

Minerals are traditionally considered to be inorganic. Although some organic materials are used as gemstones and for other decorative purposes, and some of these have a similar chemical composition to minerals, they are not true minerals. Amber is the hardened resin from trees; much amber is of Cretaceous, Palaeogene, and Neogene age and can contain fossilized insects. Jet, a soft black rock, is a type of impure coal, and became highly fashionable for jewelry in Victorian times. Shell, pearl, and coral (the use of which is not sustainable) are rich in calcite and are used decoratively.

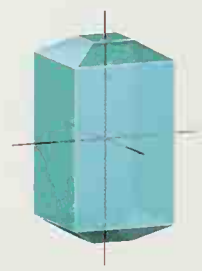
CRYSTAL SYSTEMS



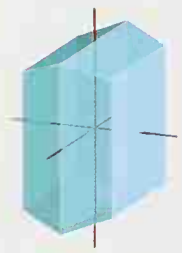
Cubic systems are common and easily recognized. Such crystals have three axes at right angles; shapes include the cube and the eight-faced octahedron.



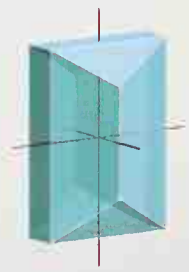
Hexagonal and trigonal systems are very similar to each other, with four axes of symmetry. Their crystals are often six-sided prisms with pyramidal tops (left).



Tetragonal systems have three axes of symmetry, all at right angles and two of equal length. In a tall prism (left), the vertical axis is longer. Squat prisms are also common.

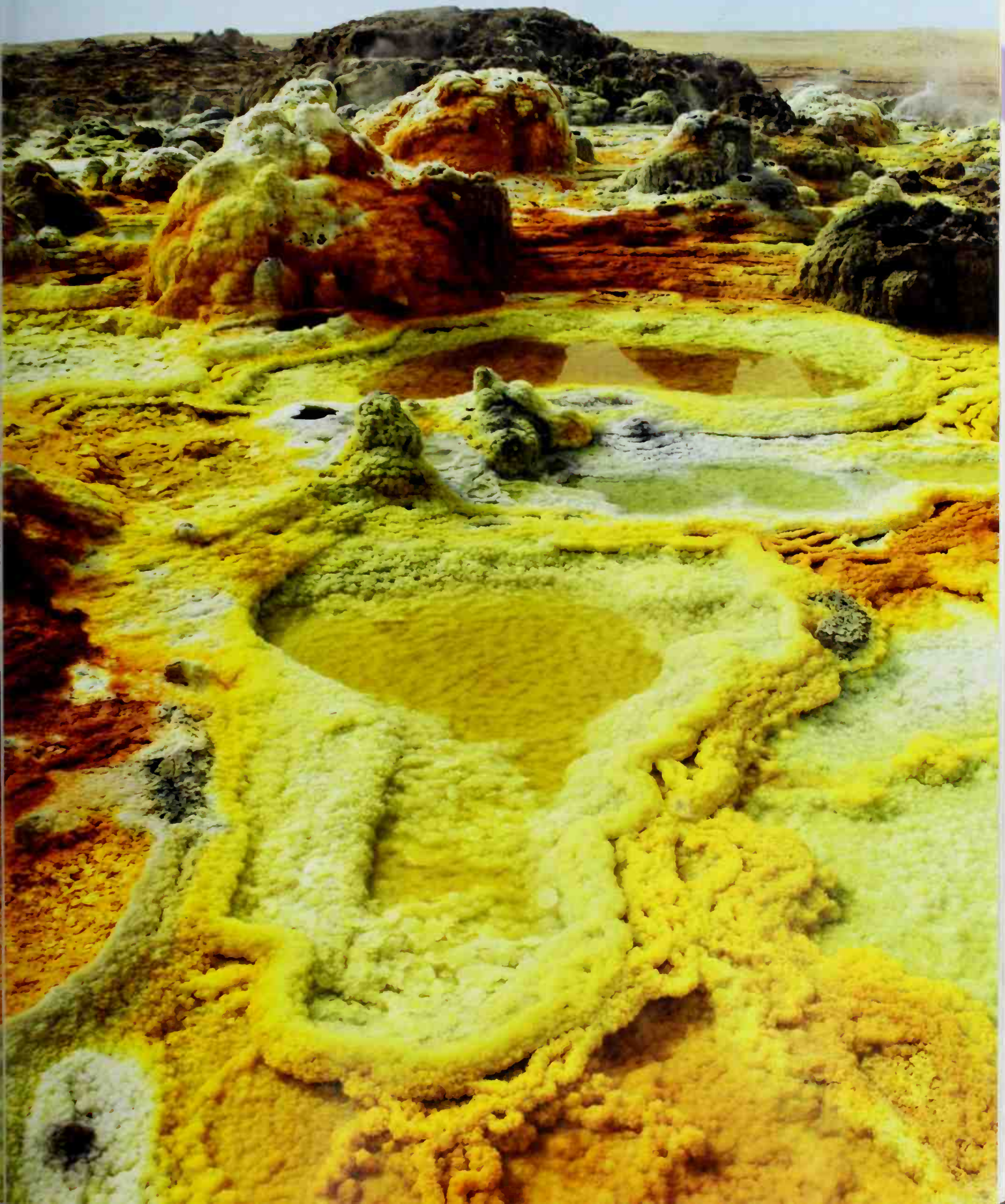


Monoclinic systems have three unequal axes of symmetry, only two at right angles. Tabular (flattened, left) and prismatic habits are common.



Orthorhombic systems are similar to the monoclinic system, but all three axes are at right angles; the usual habits are tabular and prismatic (left).

Triclinic systems have a low degree of symmetry, because the three axes are unequal in length and none of them are at right angles. Prismatic habits are common.

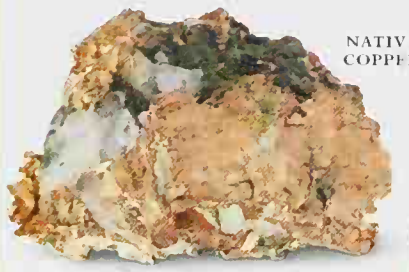


NATIVE ELEMENTS

Of the 88 natural elements, only about 20 are found in the native state; that is, uncombined with other elements. They are divided into three groups. The metals rarely form as distinct crystals, tend to have a high specific gravity, and are soft. Semimetals, such as antimony and arsenic, commonly occur in rounded masses. Nonmetals, including sulfur and carbon, usually form as crystals.

ANTIMONY
Hexagonal/trigonal
H 3–3½ • SG 6.6–6.7
This rare semimetal occurs in hydrothermal veins, often with arsenic and silver minerals. The silvery gray masses are coated white when oxidized.

GRAPHITE
Hexagonal • H 1–2 • SG 2.1–2.3
A form of pure carbon common in metamorphic rocks, graphite is dark, soft, and greasy, and makes ideal pencil leads.



NATIVE COPPER

COPPER
Cubic • H 2½–3 • SG 8.9
Native copper occurs mainly as irregular masses or branching or wirelike forms. It is most notably associated with basaltic lava. It is a good conductor and is widely used in the electrical industry.

dendritic habit

COPPER ON GOETHITE GROUNDMASS

NICKEL-IRON
Cubic
H 4–5 • SG 7.3–8.2
Iron is invariably alloyed to nickel. The mineral kamacite can have up to 7.5 percent nickel, and taenite up to 50 percent.

distinct, isolated diamond crystal

DIAMOND
Cubic • H 10 • SG 3.52
The hardest of all minerals, diamond, a valuable form of carbon, occurs in igneous rocks called kimberlites, which originate in deep volcanic pipes.

rock groundmass

resinous luster

ARSENIC
Hexagonal/trigonal • H 3½ • SG 5.7
Highly poisonous arsenic usually forms as pale gray, rounded masses in hydrothermal veins. If heated, it smells of garlic.

SULFUR
Orthorhombic • H 1½–2½ • SG 2.0–2.1
Native sulfur forms striking yellow crystals and powdery crusts around volcanic vents. It is mined for use in sulfuric acid, dyes, insecticides, and fertilizers.

PLATINUM NUGGET

PLATINUM
Cubic • H 4–4½ • SG 21.4
A rare metal, native platinum forms as scales, grains, and nuggets in igneous rocks and in alluvial sands. Its high melting point means it is useful in industry, for example in aircraft spark plugs.

uneven surface

PLATINUM

SULFIDES

The sulfides are a large group of minerals, in which sulfur is combined with one or more metals. Many sulfides have a high specific gravity and a metallic luster. They often form as excellent crystals. Sulfides occur in many geological situations, but frequently in hydrothermal veins. The group includes the majority of the economically important metal ore minerals.

GOLD IN QUARTZ

GOLD NUGGET

GOLD
Cubic • H 2½–3 • SG 19.3
Prized for its color and malleability, gold forms in hydrothermal veins and often weathers out to be found as nuggets in river sands.

CINNABAR
Hexagonal/trigonal
H 2–2½ • SG 8.0–8.2
Red-colored mercury sulfide has been the main source of mercury through the centuries. It occurs around hot springs and volcanic vents.

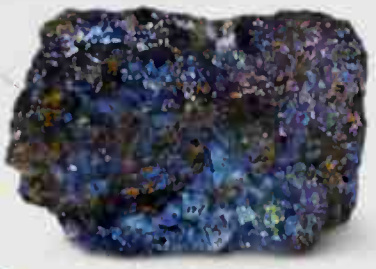
COBALTITE
Orthorhombic • H 5½ • SG 6.3
Cobaltite is an uncommon sulfide of arsenic and cobalt. It is an important cobalt ore in, for example, Sweden and Norway.

long, curved crystals resemble blades or swords

STIBNITE
Orthorhombic • H 2 • SG 4.63–4.66
A sulfide of antimony, this dark gray mineral is the main ore of antimony. Large deposits occur in the western US, China, and Japan.

IRON
Cubic • H 4 • SG 7.3–7.9
The majority of native iron is found in the Earth's core, since at the surface it readily combines with other elements.

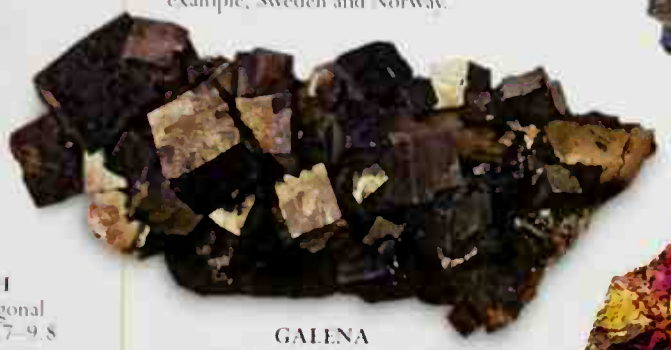
indistinguishable crystals form large masses



MASSIVE BORNITE

BORNITE CRYSTALS

BORNITE
Tetragonal • H 3 • SG 5.0–5.1
This copper iron sulfide is a coppery red color, tarnishing to shimmering purple and blue. It is an important copper ore.



GALENA
Cubic • H 2½ • SG 7.58
Lead sulfide is one of the more abundant and widely distributed sulfide minerals. It is mined extensively as lead ore.

COMMON, MASSIVE FORM OF CHALCOPYRITE

BISMUTH
Hexagonal/trigonal
H 2–2½ • SG 9.7–9.8
Native bismuth is relatively rare. Hardly ever found as distinct crystals, it more often has a granular or branching form.

mercury globules in rock cavities

MERCURY
Hexagonal/trigonal
H Liquid • SG 13.6–14.4
This is the only metal that is liquid at normal temperatures. In liquid form, mercury appears as silvery globules.

GREENOCKITE
Hexagonal
H 3–3½ • SG 4.7–4.8
Named after Lord Greenock, on whose Scottish property it was discovered in 1840, this rare cadmium sulfide can be yellow, red, or orange.

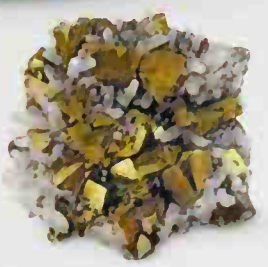
SILVER
Cubic • H 2½–3 • SG 10.5
Widely distributed but rarely found in abundance, native silver occurs mainly as twisted wires, scales, and branching masses.

USUAL, CRYSTALLINE FORM OF SPHALERITE

MASSIVE SPHALERITE

SPHALERITE
Cubic • H 3½–4 • SG 3.9–4.1
A sulfide of zinc with variable iron content, sphalerite is the most heavily mined zinc-containing ore.

ACANTHITE
Monoclinic
H 2–2½ • SG 7.22
A sulfide occurring as dark, metallic, sometimes spiky crystals, acanthite is the main ore of silver.



CHALCOPYRITE CRYSTALS

CHALCOPYRITE
Tetragonal
H 3½–4 • SG 4.3–4.4
A sulfide of copper and iron, chalcopyrite has a deep brassy yellow color. It has significant value as a copper ore.

»

» SULFIDES

ORPIMENT
Monoclinic
H 1½–2 • SG 3.4–3.5
Named from the Latin for "golden paint," this arsenic sulfide occurs as foliated, columnar masses around hot springs.

REALGAR
Monoclinic • H 1½–2 • SG 3.56
A bright orange-red sulfide of arsenic, realgar was historically used as a pigment.

GLAUCODOT
Orthorhombic • H 5 • SG 5.9–6.1
This sulfide of cobalt, iron, and arsenic occurs as silver-white brittle masses, which have no external crystal form.

MOLYBDENITE
Hexagonal/trigonal
H 1–1½ • SG 4.62–5.06
Molybdenum sulfide is lead-gray in color. It has an oily feel, which is due to weak bonds within a layered crystal structure.

MARCASITE
Orthorhombic
H 6–6½ • SG 4.92
A sulfide of iron that is lighter and more brittle than pyrite, marcasite frequently occurs as cockscombs and spear-shaped "twins."

COVELLITE
Hexagonal • H 1½–2 • SG 4.6–4.8
Covellite is a not particularly common copper sulfide. Its shining indigo-blue color makes it attractive to mineral collectors.

HAUERITE
Cubic • H 4 • SG 3.46
Hauerite is a very rare sulfide of manganese. The brown octahedral crystals can form when certain minerals are altered in the caps of salt domes.

STANNITE
Tetragonal • H 4 • SG 4.4
Stannite is a sulfide of tin, copper, and iron mined for the tin. Its name comes from the Latin for tin, *stannum*.

ARSENOPYRITE
Monoclinic
H 5½–6 • SG 5.9–6.2
Silvery-colored arsenopyrite is a sulfide of arsenic and iron. With almost 50 percent arsenic content, it is a principal ore of arsenic which is poisonous to humans.

PENTLANDITE
Cubic
H 3½–4 • SG 4.6–5.0
This nickel and iron sulfide is found in basic igneous rocks. It is an important source of nickel.

PYRITE
Cubic
H 6–6½ • SG 5
Nicknamed "fools gold" because of its light goldish color, this iron sulfide is the most common of all sulfide minerals.

PYRRHOTITE
Monoclinic • H 3½–4½ • SG 4.53–4.77
An iron sulfide with variable iron content, pyrrhotite has a magnetism that increases as the iron content decreases.

MILLERITE
Hexagonal/trigonal
H 3–3½ • SG 5.3–5.6
This sulfide of nickel occurs in limestones and ultramafic rocks. It is sought after as a nickel ore.

CHALCOCITE
Monoclinic • H 2½–3 • SG 5.5–5.8
Dark gray to black, copper sulfide has been mined for centuries. It is one of the most profitable copper ores.

SULFOSALTS

Sulfosalts are a group of about 200 mainly rare minerals, structurally related to standard sulfides and with many of the same properties. In these compounds sulfur is combined with a metallic element—commonly silver, copper, lead, or iron—and a semimetal, often antimony or arsenic. Sulfosalts frequently occur in hydrothermal veins, usually in small amounts.

BISMUTHINITE
Orthorhombic • H 2 • SG 6.8
This sulfide of bismuth is an important ore. Much of the bismuth recovered is used in medicines and cosmetics.

POLYBASITE
Monoclinic
H 2–3 • SG 6.0–6.3
Somewhat uncommon, polybasite is a sulfide of silver, copper, antimony, and arsenic. It can yield worthwhile quantities of silver locally.

BOULANGERITE
Monoclinic
H 2½–3 • SG 5.8–6.2
A bluish gray sulfide of lead and antimony, boulangerite is one of few sulfide minerals to form fine, hairlike crystals.

PYRARGYRITE
Hexagonal/trigonal
H 2½ • SG 5.8–5.9
Also called ruby silver, this sulfide of silver and antimony is red-black, but thin splinters appear deep ruby-red.

STEPHANITE
Orthorhombic
H 2–2½ • SG 6.25
Stephanite is an opaque black sulfide of silver and antimony. It can be an important silver ore—for example, in Nevada.

JAMESONITE
Monoclinic • H 2½ • SG 5.63
A sulfide of lead, iron, and antimony, jamesonite's dark gray crystals can be fine and hairlike or larger and prismatic.

PROUSTITE
Hexagonal/trigonal • H 2–2½ • SG 5.55–5.64
This sulfide of silver and arsenic is also called light ruby silver. The transparent crystals are bright scarlet-red.

ZINKENITE
Hexagonal • H 3–3½ • SG 5.3
Zinkenite is a sulfide of lead and antimony. It occurs as steel-gray hair- or needlelike crystals.

TETRAHEDRITE
Cubic
H 3–4½ • SG 4.6–5.1
This sulfide of copper, iron, and antimony is named for its tetrahedron-shaped crystals (crystals with four triangular faces).

TENNANTITE
Cubic • H 3–4½ • SG 4.59–4.75
Tennantite, a sulfide of copper, iron, and arsenic, is dark gray or black. It can look very similar to tetrahedrite.

ENARGITE
Orthorhombic • H 3 • SG 4.4–4.5
A steel-gray colored sulfide of copper and arsenic, enargite has a metallic luster. Crystals are usually small, tabular, or prismatic.

BOURNONITE
Orthorhombic • H 2½–3 • SG 5.7–5.9
Black or steel-gray bournonite is a sulfide of lead, copper, and antimony. Crystals are tabular to prismatic.

OXIDES

Oxides are compounds of oxygen and other elements. Some oxides are very hard and have a high specific gravity, and many are brightly colored. The group includes the chief ores of iron, manganese, aluminum, tin, and chromium. Some oxide minerals are sought-after gems. Oxides can occur in hydrothermal veins, igneous and metamorphic rocks, and also, because they can be resistant to weathering and transportation, in layers of sediment.

CUPRITE
Cubic • H 3½–4 • SG 6.14
Found in various shades of red, this copper oxide forms near the Earth's surface by oxidation of copper minerals.

PEROVSKITE
Orthorhombic
H 5½ • SG 4.01
Discovered in Russia in 1839, this dark-colored oxide of calcium and titanium forms in igneous and metamorphic rocks.

ILMENITE
Hexagonal/trigonal
H 5–6 • SG 4.72
Iron titanium oxide is the principal ore of titanium, a high strength, low density metal used in aircraft and rocket construction.

octahedral franklinite crystal

FRANKLINITE
Cubic
H 5½–6½ • SG 5.07–5.22
This black or brown zinc manganese iron oxide is found in metamorphosed limestones, notably those in Franklin, New Jersey.

CASSITERITE
Tetragonal • H 6–7 • SG 7
Almost the sole source of the world's tin, this tin oxide is mainly found as small grains among river gravels.

URANINITE
Cubic • H 5–6 • SG 6.5–10.0
Highly radioactive, black- or brown-colored uranium oxide is the main ore of uranium, which is used in nuclear reactors to produce electricity, and in the construction of nuclear weapons.

striated crystal face

vitreous luster

SAMARSKITE
Orthorhombic
H 5–6 • SG 5.15–5.69
Minerals known as samarskite—a radioactive oxide of various metals including yttrium, iron, tantalum, and niobium—occur in igneous rocks and alluvial sands.

GAHNITE
Cubic • H 7½–8 • SG 4.6
A rare oxide of aluminum and zinc found mainly in metamorphic rocks, gahnite can form dark green or blue to black crystals.

CORUNDUM
Hexagonal/trigonal
H 9 • SG 4.0–4.1
Corundum is an aluminum oxide, second only in hardness to diamond. Ruby-red and sapphire-blue varieties are used as gemstones.

CHROMITE
Cubic • H 5½ • SG 4.5–4.8
This iron chromium oxide is the only important source of chromium, an element used in making chrome- and stainless-steel.

HYDROXIDES

Hydroxide minerals are compounds of a metallic element and the hydroxyl radical (OH). They are common minerals and often form through a chemical reaction between an existing oxide and fluids rich in water, seeping through the Earth's crust. Many hydroxide minerals are quite soft. Hydroxides tend to occur in the altered parts of hydrothermal veins and in metamorphic rocks.

HEMATITE
Hexagonal • H 5–6 • SG 5.26
Widespread and abundant, iron oxide is mined extensively for iron. Various forms range in color from metallic gray to earthy red.

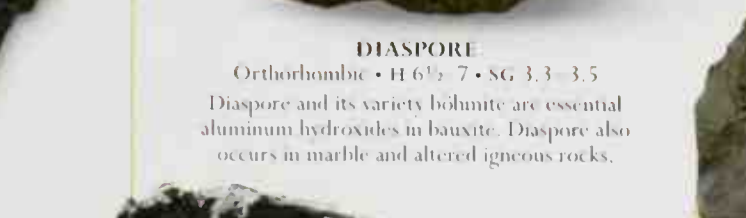
STIBICONITE
Cubic • H 4–5½ • SG 3.3–5.5
An uncommon hydroxide of antimony, stibiconite is white or yellowish brown, and forms by the alteration of other antimony minerals, especially stibnite.

GIBBSITE
Monoclinic
H 2½–3½ • SG 2.4
Gibbsite is one of three essential aluminum hydroxides in the aluminum ore bauxite. It also occurs in hydrothermal veins.

FERGUSONITE
Tetragonal
H 5½–6½ • SG 4.2–5.7
Fergusonite is the group name for an oxide of many metals, including yttrium, lanthanum, niobium, and cerium.

LEPIDOCROCITE
Orthorhombic • H 5 • SG 3.9
This relatively rare iron hydroxide may occur with goethite. It is reddish brown and can form irregular and fibrous shapes.

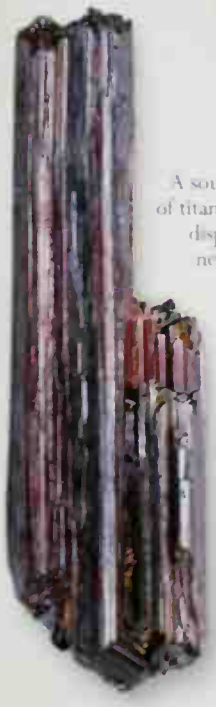
PYROLUSITE
Tetragonal
H 2–6½ • SG 5.06
Pyrolusite is a common manganese oxide. It is the primary ore of manganese, an essential element in steel production.



DIASPORE
Orthorhombic • H 6½–7 • SG 3.3–3.5
Diaspore and its variety böhmite are essential aluminum hydroxides in bauxite. Diaspore also occurs in marble and altered igneous rocks.

MASSIVE ROMANÈCHITE

ROMANÈCHITE
Orthorhombic • H 5–6 • SG 4.7
Dark and opaque, this oxide of manganese with barium is usually found in aggregates or in massive forms. Crystals are rare.



RUTILE
Tetragonal
H 6–6½ • SG 4.23
A source of titanium, this oxide of titanium often forms impressive displays of thin, translucent needles in quartz crystals.

BOTRYOIDAL GOETHITE

MASSIVE GOETHITE

GOETHITE
Orthorhombic • H 5–5½ • SG 3.3–4.3
A common iron hydroxide, goethite gives a yellow-brown color to soil and rocks that have been exposed to the atmosphere.

BAUXITE
Amorphous mixture
H 1–3 • SG 2.3–2.7
The primary aluminum ore, bauxite is not a single mineral, but rather an assemblage of aluminum hydroxides and iron oxides.

BRUCITE
Hexagonal/trigonal • H 2½ • SG 2.38–2.40
Brucite is a magnesium hydroxide, and its color is white, gray, blue, or green. It occurs in metamorphic rocks.

CHRYSOBERYL
Orthorhombic • H 8½ • SG 3.7–3.8
Chrysoberyl is beryllium aluminum oxide. It is a prized gemstone, known for its exceptional hardness and green or yellow-brown color.

ZINCITE
Trigonal • H 4–4½ • SG 5.68
Zincite is a rare oxide of zinc and manganese. Its only significant deposit in the US has been exhausted.

HALIDES

When metallic elements combine with halogen elements, halides are formed. The halogens are iodine, fluorine, chlorine, and bromine. Halide minerals are commonly very soft and of low specific gravity, often having crystals classified in the cubic system. Many of these minerals, such as halite and sylvite, form in evaporite sequences by the drying out of saline waters. Other halides—for example, fluorite— occur in hydrothermal veins.

YELLOW FLUORITE

PURPLE FLUORITE

cubic crystal

SYLVITE
Cubic • H 2 • SG 1.99
Sylvite is potassium chloride, a salt similar to halite. It occurs with halite in evaporite deposits. Sylvite is used to make potash fertilizers.

FLUORITE
Cubic • H 4 • SG 3.18
Calcium fluoride often forms transparent to translucent crystals of various colors. Large quantities are used for making hydrofluoric acid.

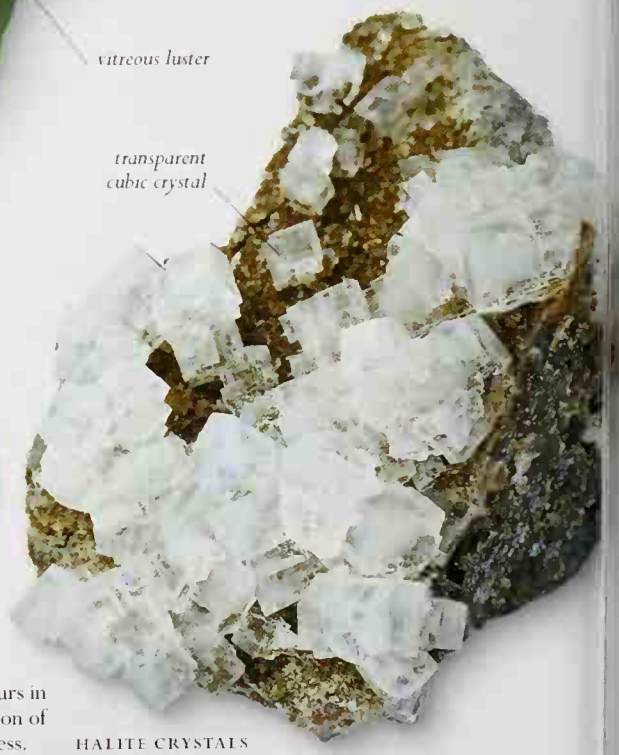
GREEN FLUORITE

granular carnallite

CARNALLITE
Orthorhombic • H 2 • SG 1.6
Carnallite is a hydrated chloride of magnesium and potassium, formed by the evaporation of saline water. It is important in fertilizer manufacture.

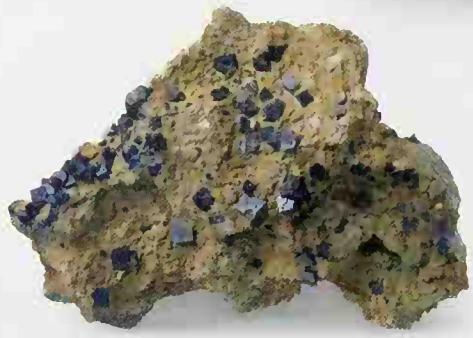
vitreous luster

transparent cubic crystal



HALITE CRYSTALS

DIABOLEITE
Tetragonal • H 2½ • SG 5.42
A lead copper chloride hydroxide with a light to dark blue color, diaboleite forms by the alteration of other minerals.



BOLEITE
Cubic • H 3–3½ • SG 5.0–5.1
Deep blue boleite is a rare hydroxide of lead, silver, copper, and chlorine. It occurs where lead and copper deposits have been altered.

ORANGE HALITE

HALITE
Cubic • H 2 • SG 2.1–2.2
Common salt, or sodium chloride, occurs in extensive beds formed by the evaporation of sea water. It can be colored or colorless.

CARBONATES

Carbonate minerals are compounds of metallic or semimetallic elements combined with the carbonate radical (CO_3). Over 70 carbonate minerals are known, but calcite, dolomite, and siderite account for most of the carbonate in the Earth's crust. Carbonates usually form as "good" crystals with regular shapes and no foreign substances enclosed within them. Many carbonates are pale colored, but some, such as rhodochrosite, smithsonite, and malachite, are brightly colored.

JARLITE
Monoclinic
H 4—4½ • SG 3.82
Usually white, jarlite is found in igneous rocks. It is a rare sodium strontium magnesium aluminum fluoride hydroxide.

CHLORARGYRITE
Cubic • H 2½ • SG 5.55
This silver chloride is typically scaly, platelike, or, in masses, resembling wax. It occurs where silver deposits are altered.

ATACAMITE
Orthorhombic • H 3—3½ • SG 3.76
Green atacamite is copper chloride hydroxide, occurring where copper deposits have been oxidized. It is a minor copper ore.

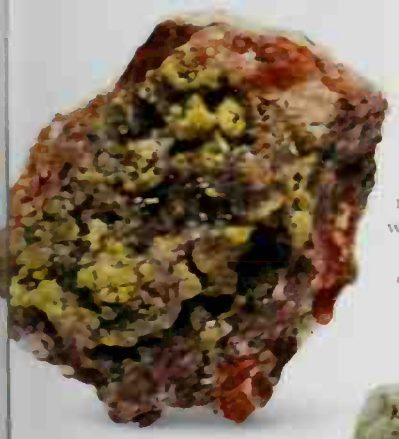
TRONA
Monoclinic • H 2½—3 • SG 2.1
Hydrated sodium carbonate, or trona, is gray, yellowish, or brown. It forms on the Earth's surface, especially in saline desert environments.

SMITHSONITE
Hexagonal/trigonal
H 4—4½ • SG 4.3—4.45
A zinc carbonate found in the upper oxidized zones of zinc ore deposits, smithsonite is also mined for zinc.

CALCITE
Hexagonal/trigonal
H 3 • SG 2.71
One of the most abundant minerals, most calcium carbonate is massive, occurring as limestone or marble. It can also form outstanding crystals.

BARYTOCALCITE
Monoclinic • H 4 • SG 3.66—3.71
This barium calcium carbonate is white to yellowish, and often found in hydrothermal veins within limestone.

DOLOMITE
Hexagonal/trigonal
H 3½—4 • SG 2.85
Dolomite is a calcium magnesium carbonate widespread in altered limestones. Dolomite rock, formed exclusively of massive dolomite, is used as a building stone.



CALOMEL
Tetragonal
H 1—2 • SG 6.5
Rarely found, this mercury chloride is a white to gray or brown mineral. Its color deepens on exposure to light.

CRYOLITE
Monoclinic
H 2½ • SG 2.97
A rare aluminum sodium fluoride, cryolite often has an icelike appearance. It is found in granitic pegmatites and granites.

WITHERITE
Orthorhombic
H 3—3½ • SG 4.29
Reasonably uncommon, this carbonate of barium tends to be white or gray, and occurs in hydrothermal veins.

MAGNESITE
Hexagonal/trigonal • H 3—4 • SG 3.0—3.1
A magnesium carbonate, magnesite usually occurs as white to brownish dense masses. It is made into furnace bricks and magnesia cement.

STRONTIANITE
Orthorhombic • H 3½ • SG 3.78
This strontium carbonate is found in hydrothermal veins and limestones. The strontium is used in sugar refining and fireworks.

»

FLOS FERRI ("FLOWERS OF IRON") ARAGONITE

ARAGONITE
Orthorhombic
H 3½–4 • SG 2.94–2.95

Aragonite is calcium carbonate, chemically identical to calcite, but with a different crystal structure and much less common.

BOTRYOIDAL SIDERITE

SIDERITE
Hexagonal/trigonal
H 4 • SG 3.96

A brown-colored carbonate of iron, named from the Greek for iron, *sideros*, siderite occurs in a variety of forms.

RHOMBOHEDRAL SIDERITE

ARAGONITE TWINNED CRYSTALS

short prismatic crystals

PHOSGENITE
Tetragonal • H 2½–3 • SG 6.1

This rare lead carbonate chloride is formed close to the Earth's surface by the reaction of lead-rich minerals with water.

ARTINITE
Monoclinic • H 2½ • SG 2

A hydrated magnesium carbonate hydroxide, artinite has a distinctive habit, with sprays of white, needle-shaped crystals. It occurs in serpentine rocks.

HYDROZINCITE
Monoclinic
H 2–2½ • SG 4

Hydrozincite, or zinc carbonate hydroxide, is pale gray, white, pink, or yellowish. It fluoresces bluish white under ultraviolet light.

glasslike sheen

patch of green malachite around margins

limonite matrix

AZURITE
Monoclinic • H 3½–4 • SG 3.77–3.78

Azurite is a hydrous copper carbonate. Its rich blue color and frequent association with green malachite in hydrothermal veins are distinctive features.

botryoidal habit

LEADHILLITE
Monoclinic • H 2½–3 • SG 6.55

This lead sulfate carbonate hydroxide usually occurs as well-formed crystals in the oxidized zones of lead deposits.

CLUSTER OF TWINNED CRYSTALS

CERUSSITE CRYSTALS

CERUSSITE
Orthorhombic • H 3–3½ • SG 6.55
A carbonate of lead occurring where lead-bearing veins have been altered, cerussite is the most common lead ore after galena.

rhombohedral crystals

ANKERITE
Hexagonal/trigonal
H 3½–4 • SG 2.97
Ankerite is a carbonate of calcium with lesser iron, magnesium, and manganese. It is sometimes found in gold-bearing quartz veins.

RHODOCHROSITE
Hexagonal/trigonal • H 3½–4 • SG 3.7
Gem-quality crystals of this manganese carbonate, in shades of rose-pink, can be found in the US, South Africa, and Peru.

aurichalcite crystals

characteristic green coloring

associated azurite

MALACHITE
Monoclinic • H 3½–4 • SG 4
This striking green copper carbonate often occurs as rounded masses. It is used for ornamentation and as a source of copper.

BOTRYOIDAL MALACHITE

AURICHALCITE
Monoclinic • H 1–2 • SG 3.96
A blue- or green-colored zinc copper carbonate hydroxide, aurichalcite forms in the oxidized zones of zinc and copper deposits.

MALACHITE ON CHRYSOCOLLA (SILICATE MINERAL)

BORATES

Borates occur when metallic elements combine with the borate radical (BO_3). There are over 100 borate minerals, the most common being borax, kernite, ulexite, and colemanite. Borates tend to be pale colored, relatively soft, and have low specific gravity. Many occur in evaporite sequences where saline waters have dried out and minerals are then precipitated among layers of sedimentary rocks.

BORACITE
Orthorhombic
H 7–7½ • SG 3
Magnesium borate chloride crystals are pale green or white, and glassy. Boracite occurs in salt deposits, notably in Germany and Poland.

translucent, prismatic crystals

COLEMANITE
Monoclinic • H 4½ • SG 2.42
This hydrated calcium borate hydroxide forms when saline water evaporates. It was the main source of boron until the discovery of kernite.

KERNITE
Monoclinic • H 2½–3 • SG 1.9
A colorless or white sodium borate hydrate, kernite has less water than borax. The two minerals occur together.

ULEXITE
Monoclinic • H 2½ • SG 1.96
A hydrated sodium calcium borate hydroxide, ulexite's white, fibrous crystals transmit light down their length. It has uses similar to borax.

BORAX
Monoclinic • H 2–2½ • SG 1.7
A chalky-white sodium borate hydrate, borax has many applications, including in medicines, laundry detergents, glasses, and textiles.

HOWLITE
Monoclinic • H 3½ • SG 2.6
Howlite is calcium borosilicate hydroxide. It generally forms as chalky, rounded masses.

NITRATES

Nitrates are a small group of compounds where metallic elements combine with the nitrate radical (NO_3). These minerals are usually very soft and have low specific gravity. Many dissolve easily in water and they only rarely form as crystals. They are generally confined to arid regions, forming coatings on the land surface that often cover wide areas. Commercially, nitrates can be used as fertilizers or explosives.

NITRATITE
Hexagonal/trigonal • H 1½–2 • SG 2.27
Sodium nitrate typically occurs as crusts on the ground surface in arid regions, especially in Chile. It is white, gray, brown, or yellow.

SULFATES

Sulfates are composed of metals joined to the sulfate radical (SO_4). There are about 200 sulfates and most are rare. Many, such as the more common gypsum, form in evaporite deposits where minerals are precipitated from drying saline solutions. Others form as weathering products, or as primary minerals in hydrothermal veins. Many are economically important—barite is used to lubricate drills on oil rigs.

RADIATING GYPSUM

SATIN SPAR

GYPSUM
Monoclinic • H 2 • SG 2.32
A widespread mineral, gypsum, or hydrated calcium sulfate, makes plaster of Paris when heated and mixed with water.

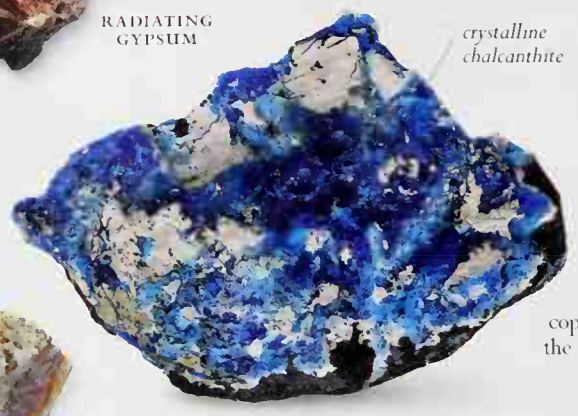
THENARDITE
Orthorhombic
H 2½–3 • SG 2.66
A pale gray or brownish mineral, thenardite is sodium sulfate. It is found on lava flows and around salt lakes.

prismatic crystal

galena

ANGLESITE
Orthorhombic
H 2½–3 • SG 6.3–6.4
This lead sulfate comes in a variety of colors and forms. It is an alteration product of galena, the primary lead ore.

crystalline chalcanthite



CHALCANTHITE
Triclinic
H 2½ • SG 2.28
Rich blue or green chalcanthite is hydrated copper sulfate. It forms through the oxidation of chalcopyrite and other copper sulfates.

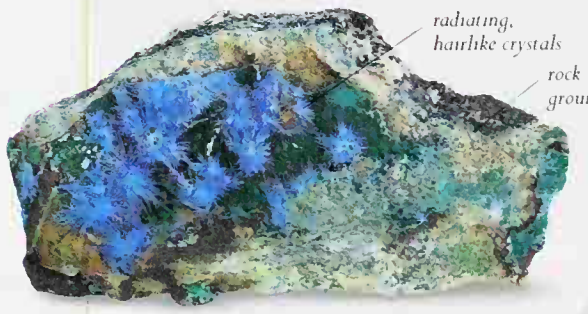
LINARITE
Monoclinic
H 2½ • SG 5.3
Bright blue linarite is hydrous copper lead sulfate. It occurs in the oxidation zones of copper and lead ores.

mass of needle-shaped brochantite crystals

ALUNITE
Hexagonal/trigonal
H 3½–4 • SG 2.6–2.9
A hydrous sulfate of potassium and aluminum, alunite may be found at volcanic vents where rocks are altered by sulfur vapors.

radiating, hairlike crystals

rock groundmass



CYANOTRICHITE
Orthorhombic • H 3 • SG 2.74–2.95
This hydrated copper aluminum sulfate is named after the Greek for "blue" and "hair," referring to its clusters of fine, blue crystals.

GLAUBERITE
Monoclinic
H 2½–3 • SG 2.8
Glauberite is sodium and calcium sulfate. Colorless, gray, or yellowish, it forms where saline water evaporates.

CHROMATES

Chromate minerals form when metallic elements join with the chromate radical (CrO_4). They are rare minerals—crocoite is the only reasonably well-known chromate. They are generally brightly colored, and highly sought after by mineral collectors. Chromates often form when hydrothermal veins are altered by fluids.

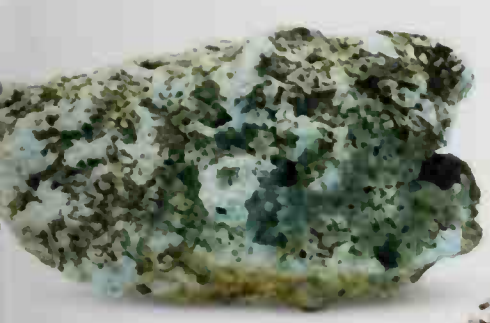
RED CROCOITE

slender, elongate crystals with striations

adamantine luster

ORANGE CROCOITE

CROCOITE
Monoclinic • H 2½–3 • SG 6
Orange or red lead chromate forms in the oxidized zones of lead deposits. Good specimens come from Australia.



MELANTERITE
Monoclinic • H 2 • SG 1.9
White, green, or blue melanterite is hydrated iron sulfate. It is used in purifying water supplies, and as a fertilizer.

EPSOMITE
Orthorhombic
H 2–2½ • SG 1.68
This hydrated magnesium sulfate occurs in arid regions and limestone cave walls. It is the source of Epsom salts.

JAROSITE
Hexagonal/trigonal
H 2½–3½ • SG 2.90–3.26
Jarosite is a hydrous sulfate of iron and potassium, occurring as brown coatings on pyrite and other iron minerals.

CELESTINE
Orthorhombic • H 3–3½ • SG 3.96–3.98
Strontium sulfate is sought after, not only as the main source of strontium, but also for the beautiful, transparent, pale-colored crystals.

COPIAPITE
Triclinic • H 2½–3 • SG 2.08–2.17
A yellow or green hydrated sulfate of iron first described from Copiapó, Chile, copiapite occurs where other minerals are altered.

BROCHANTITE
Monoclinic
H 3½–4 • SG 3.97
A copper sulfate hydroxide, brochantite forms emerald-green crystals, crusts, or masses.

ANHYDRITE
Orthorhombic
H 3–3½ • SG 2.98
A form of calcium sulfate, anhydrite occurs alongside gypsum but is less common. It alters to gypsum in humid conditions.

BARITE
Orthorhombic
H 3–3½ • SG 4.5
The most common barium mineral, barium sulfate is unusually heavy for a pale-colored mineral.

POLYHALITE
Triclinic • H 3½ • SG 2.78
Polyhalite is hydrated potassium calcium magnesium sulfate. Colorless, white, pink, or red, it is widespread in many marine salt deposits.

MOLYBDATES

Molybdates form when metals combine with the molybdate radical (MoO_4). These minerals are rare and tend to be dense and brightly colored. Molybdate minerals occur in mineral veins that have been altered by circulating water. Wulfenite is the best-known molybdate mineral. It is prized for its fine crystals and brilliant orange or yellow colors.

WULFENITE
Tetragonal • H 2½–3 • SG 6.5–7.0
This lead molybdate is found in oxidized zones of lead and molybdenum deposits. It is a minor source of molybdenum.

TUNGSTATES

Tungstate minerals are compounds with metallic elements joined to the tungstate radical (WO_4). These minerals are rare and usually brittle and dense. Some are dark colored and form as fine crystals. Tungstates occur in hydrothermal veins and pegmatites—very coarse-grained granitic rocks where minerals form from fluids permeating the rock.

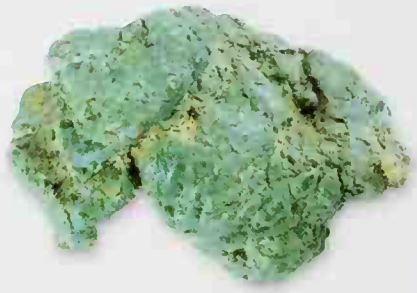
SCHEELITE
Tetragonal
H 4½–5 • SG 5.9–6.1
Mined for tungsten, this calcium tungstate is found in hydrothermal veins, metamorphic and igneous rocks, and alluvial sands.

HÜBNERITE
Monoclinic
H 4–4½ • SG 7.3
This manganese iron tungstate is a major source of tungsten, a metal used in steel alloys, abrasives, and light bulbs.

FERBERITE
Monoclinic
H 4–4½ • SG 7.5
Opaque black ferberite is found in hydrothermal veins and granitic pegmatites. It is iron tungstate, mined as a source of tungsten.

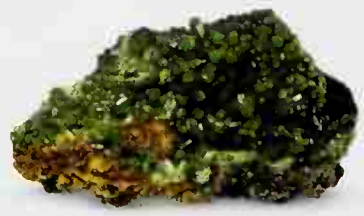
PHOSPHATES

When metals combine with the phosphate radical (PO_4), phosphate minerals are formed. These minerals form a large group of over 200—however, many are very rare. Minerals in this group vary in hardness and specific gravity, and many are brightly colored. They usually form by the alteration of sulfide minerals, but some are primary minerals. A number of phosphates are rich in lead; others are radioactive.



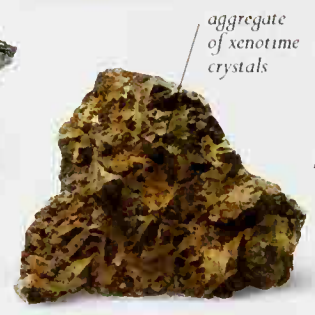
TURQUOISE
Triclinic • H 5–6 • SG 2.6–2.8
A sought after gem for thousands of years, this hydrated phosphate of copper and aluminum is found in altered igneous rocks.

HYDROXYLHERDERITE
Monoclinic • H 5–5½ • SG 2.95–3.01
Hydroxylherderite is calcium beryllium phosphate. It occurs as pale yellow or greenish crystals, with a glassy sheen, in granitic pegmatites.

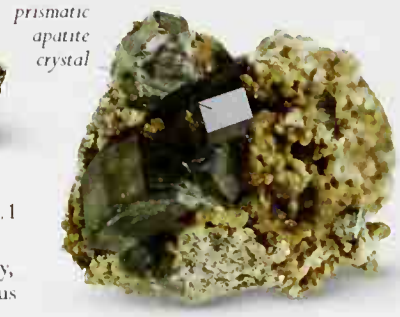


PYROMORPHITE
Hexagonal • H 3½–4 • SG 6.5–7.1
A lead phosphate chloride, variably colored greenish, orange, yellowish or brownish, pyromorphite forms in the oxidized zones of lead deposits.

DUFRÉNITE
Monoclinic • H 3½–4½ • SG 3.1–3.34
This hydrated phosphate of iron and calcium mainly occurs as green to black masses or crusts in altered veins and iron ores.



XENOTIME
Tetragonal • H 4–5 • SG 4.4–5.1
Widely distributed yttrium phosphate is yellow-brown, gray, or greenish, and forms in igneous and metamorphic rocks.



APATITE
Hexagonal/monoclinic
H 5 • SG 3.1–3.2
Apatite is the group name used for three structurally identical calcium phosphate minerals: fluorapatite, chlorapatite, and hydroxylapatite.

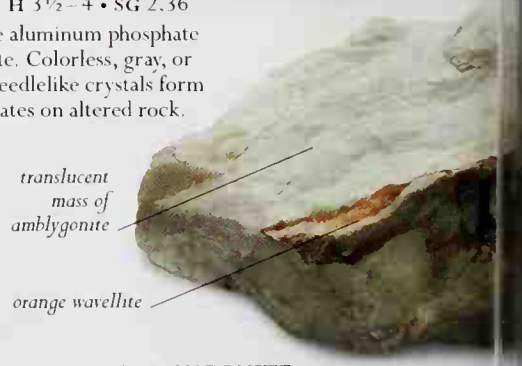
META-AUTUNITE
Tetragonal
H 2–2½ • SG 3.05–3.2
Radioactive meta-autunite is a lemon-yellow or pale green hydrated phosphate of calcium and uranium. It occurs where uranium minerals are altered.

METATORBERNITE
Tetragonal • H 2–2½ • SG 3.22
This copper uranyl phosphate hydrate is related to meta-autunite and occurs in similar settings. It is distinguished by its green color.

WAVELLITE
Orthorhombic • H 3½–4 • SG 2.36
Wavellite is a rare aluminum phosphate hydroxide hydrate. Colorless, gray, or greenish, glassy, needlelike crystals form radiating aggregates on altered rock.

VARISCITE
Orthorhombic
H 3½–4½ • SG 2.6–2.9
A semiprecious gemstone, this hydrated aluminum phosphate usually occurs as green, fine-grained masses in nodules, veins, or crusts.

TRIPLITE
Monoclinic • H 5–5½ • SG 3.5–3.9
Triplite is a phosphate of manganese, sometimes with iron and magnesium. It forms in granitic pegmatites.



AMBLYGONITE
Triclinic • H 5½–6 • SG 3.08
This rare lithium sodium aluminum fluophosphate mainly forms as masses, but crystals occur in Zimbabwe and Brazil.

VIVIANITE
Monoclinic • H 1½–2 • SG 2.68
Vivianite is hydrated iron phosphate. It commonly forms as clusters of dark prismatic crystals in altered iron deposits.

radiating acicular (needle-shaped) crystals

libethenite crystal

LIBETHENITE
Orthorhombic
H 4 • SG 4
Libethenite is a light to dark green copper phosphate hydroxide. It forms in the upper oxidized zone of copper deposits.

MONAZITE
Monoclinic • H 5–5½ • SG 4.6–5.4
Phosphate minerals containing either cerium, lanthanum, or neodymium are all referred to as monazite. They are mined for the various elements.

BRAZILIANITE
Monoclinic • H 5½ • SG 3
First discovered in Brazil, this sodium aluminum phosphate hydroxide is yellow or greenish and forms in cavities in granitic pegmatites.

bipyramidal crystal

LAZULITE
Monoclinic
H 5½–6 • SG 3.1
A relatively rare, semiprecious blue gemstone, this iron magnesium aluminum phosphate hydroxide occurs in metamorphic and igneous rocks.

VANADINITE
Hexagonal • H 3 • SG 6.88
Relatively rare lead vanadate chloride forms crystals in altered lead deposits. It is an important source of vanadium, used in steel alloys.

VANADATES

Vanadates are formed by the combination of metallic elements and the vanadate radical (VO_4). This group of minerals contains many rare examples, which tend to be dense and brightly colored. Vanadates often form when hydrothermal veins are altered by permeating fluids. Most vanadates have no commercial value; however, carnotite is an important source of uranium.

powdery crust on sandstone

CARNOTITE
Monoclinic • H 2 • SG 4.75
Generally occurring as powdery yellow crusts in uranium deposits, radioactive carnotite is a hydrated vanadate of potassium and uranium.

TYUYAMUNITE
Orthorhombic
H 2 • SG 3.3–3.6
This rare hydrated vanadate of calcium and uranium looks similar to carnotite, and also occurs in altered uranium deposits.

ARSENATES

Arsenates are mostly rare minerals composed of metallic elements and the arsenate radical (AsO_3 or AsO_4). They generally have a fairly high specific gravity and low hardness. Many arsenates have bright colors—adamite is yellow or green, and clinoclase is green or blue. This group of minerals occurs in a variety of geological situations, but many arsenates occur in altered metal deposits.

ADAMITE
Orthorhombic
H 3½ • SG 4.3–4.4
Zinc arsenate hydroxide occurs in altered arsenic and zinc deposits, sometimes as exceptional crystals.

ERYTHRITE
Monoclinic • H 1½–2½ • SG 3.18
Hydrated cobalt arsenate forms purple-pink crystals or coatings. Excellent examples occur in Canada and Morocco.

radiating clusters of clinoclase crystals

BAYLDONITE
Monoclinic
H 4½ • SG 5.6–5.7
This hydrated arsenate of copper, lead, and zinc is usually found as green or yellow crusts in altered hydrothermal veins.

olivenite crystals

OLIVENITE
Orthorhombic
H 3 • SG 4.4
Olivenite is copper arsenate hydroxide. It can be greenish, brownish, yellow, or gray and occurs in altered copper deposits.

quartz

CLINOCLASE
Monoclinic • H 2½–3 • SG 4.33
Clinoclase is a dark blue-green copper arsenate hydroxide that has a variety of forms in altered copper sulfide deposits.

MIMETITE
Hexagonal • H 3½–4 • SG 7.0–7.3
Unusual, barrel-shaped crystals characterize this lead arsenate chloride, although other forms also exist. Mimetite occurs in altered lead deposits.

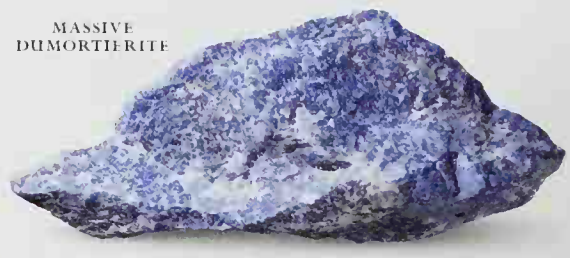
CHALCOPHYLLITE
Hexagonal/trigonal • H 2 • SG 2.7
Bright blue-green chalcophyllite is a copper aluminum arsenate sulfate hydrate. It forms in oxidized copper deposits.

SILICATES

Silicates are the most common and largest group of minerals. The fundamental building blocks are tetrahedra of silicon and oxygen (SiO_4) together with other elements. They are subdivided into six groups based on the arrangement of the silica tetrahedral. Some form as isolated tetrahedra (nesosilicates), some occur in pairs (sorosilicates), and others have a three-dimensional network of tetrahedra (tectosilicates). Some silicates form as chains of tetrahedra (inosilicates), while others form as sheets (phyllosilicates) or rings (cyclosilicates).

NESOSILICATES

ANDRADITE
Cubic • H 6½–7 • SG 3.8
Yellowish green, brown, or black, andradite garnet is a calcium iron silicate. Cut gems are excellent at separating white light into colors.

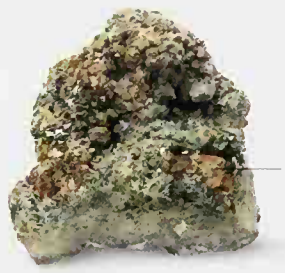


MASSIVE DUMORTIERITE

DUMORTIERITE
Orthorhombic • H 8½ • SG 3.41
Dumortierite is a silicate of aluminum, iron, and boron. It usually forms fibrous aggregates of radiating crystals, but it can also be massive.

EUCLASE
Monoclinic
H 7½ • SG 3.05–3.10
Euclase is a beryllium aluminum silicate hydroxide. It may form white, colorless, green, or blue prismatic, striated crystals.

NORBERGITE
Orthorhombic
H 6–6½ • SG 3.1–3.2
Norbergite mainly occurs as brownish yellow, white, or pink granular masses in metamorphic rocks. It is a magnesium silicate fluohydroxide.

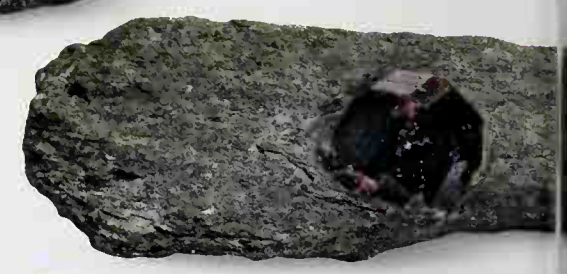


HUMITE
Orthorhombic • H 6 • SG 3.24
A magnesium iron silicate fluohydroxide, humite generally occurs as yellow to orange granular masses in metamorphosed limestones and dolomites.

PYROPE
Cubic • H 7–7½ • SG 3.6
Pyrope garnet is a dark red magnesium aluminum silicate. It forms at high pressures in metamorphic and some igneous rocks.

KYANITE
Triclinic • H 5½–7 • SG 3.53–3.67
Kyanite is an aluminum silicate. Its bladed crystals in schist and gneiss formed at high pressures in the Earth.

DATOLITE
Monoclinic
H 5–5½ • SG 2.8–3.0
Datolite is a hydrous calcium boron silicate. Not very common, it is mainly found in veins or cavities in igneous rocks.



ALMANDINE
Cubic • H 7–7½ • SG 4.3
The most common garnet, pinkish red almandine is an iron aluminum silicate. It is widely used as a gem.

GREEN GROSSULAR

RED GROSSULAR

GROSSULAR
Cubic • H 6½–7 • SG 3.6
Grossular garnet is a silicate of calcium and aluminum that sometimes forms in marble. It comes in a wide range of colors.

SOROSILICATES

OLIVINE
Orthorhombic
H 6½–7 • SG 3.27–4.32

Common in igneous rocks, nesosilicate minerals varying in composition from magnesium silicate to iron silicate are called olivine.

TOPAZ
Orthorhombic • H 8 • SG 3.49–3.57

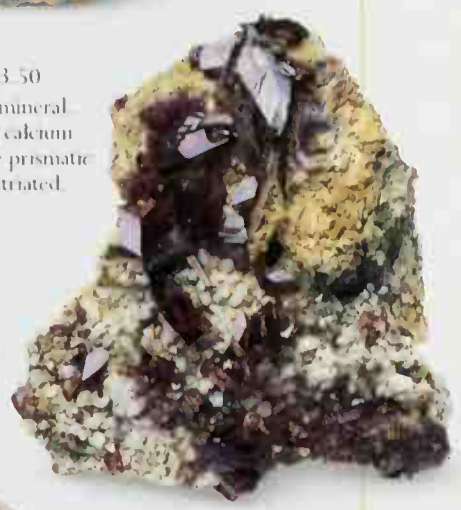
Topaz is aluminum silicate fluoride hydroxide. Crystal size is usually small, but a giant crystal weighing 596 lb (271 kg) is known from Brazil.

EPIDOTE
Monoclinic
H 6–7 • SG 3.35–3.50

Epidote is an abundant mineral. Crystals of this hydrous calcium aluminum iron silicate are prismatic or tabular, green, and striated.

AXINITE
Triclinic
H 6–7 • SG 3.2–3.4

Axinite is a hydrous calcium iron manganese aluminum boron silicate, with axe-head shaped crystals.



TITANITE
Monoclinic • H 5–5½ • SG 3.5–3.6

Variable in color, titanite is calcium titanium silicate. It is excellent at dispersing light—even better than diamond.

CHLORITOID
Monoclinic/triclinic • H 6½ • SG 3.6

Widespread in metamorphic and volcanic rocks, chloritoid is a dark green or black hydrous aluminum silicate of iron, magnesium, and manganese.

ANDALUSITE
Orthorhombic
H 6½–7½ • SG 3.13–3.16

Andalusite is an aluminum silicate. It occurs mainly in low-grade metamorphic rocks as coarse prismatic crystals with a square cross section.

ZIRCON
Tetragonal • H 7½ • SG 4.6–4.7

Zircon, or zirconium silicate, is a gem used extensively in jewelry. It is also the main source of the metal zirconium, used in nuclear reactors.

WILLEMITE
Hexagonal/trigonal
H 5½ • SG 3.89–4.19

Willemite is zinc silicate. White, green, yellow, or reddish, and usually massive, it occurs in altered zinc deposits and metamorphosed limestone.

SILLIMANITE
Orthorhombic • H 6½–7½ • SG 3.23–3.27

Sillimanite is an aluminum silicate with long, slender crystals. Its composition is identical to andalusite, but it forms at higher temperatures and pressures.

HEMIMORPHITE
Orthorhombic
H 4½–5 • SG 3.4–3.5

This hydrated silicate of zinc occurs in altered zinc deposits. It is very variable both in its color and form.

DANBURITE
Orthorhombic
H 7–7½ • SG 3

Danburite is a calcium boron silicate. Its variably colored crystals resemble topaz, but it can also be granular.

VESUVIANITE
Tetragonal/monoclinic
H 6–7 • SG 3.33–3.45

Vesuvianite is a hydrous calcium magnesium iron aluminum silicate, with fluorine. Green or yellow, it occurs in marble and igneous rocks.

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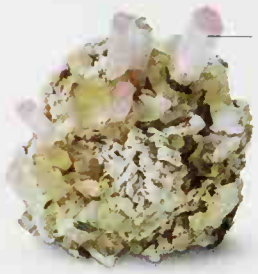
CYCLOSILICATES

BENITOITE
Hexagonal
H 6–6½ • SG 3.64–3.68
This usually blue barium titanium silicate occurs in serpentinite and veins in schist. Gem-quality crystals come from California.

six-sided crystal



TOURMALINE
Hexagonal/trigonal
H 7–7½ • SG 3.0–3.2
Tourmaline is the name for a group of 11 hydrous boron silicate minerals with the same crystal structure but varying chemistry.

prismatic crystal

AQUAMARINE

EMERALD

BERYL
Hexagonal
H 6½–8 • SG 2.6–3.0
Beryllium aluminum silicate is both a source of beryllium and a gemstone. Gem varieties include emerald (green), sapphire (blue), and aquamarine (greenish blue).

MORGANITE
Hexagonal
H 7½–8 • SG 2.6–2.8
Morganite is a pink variety of beryl, colored by additional cesium or manganese. It forms tabular crystals in pegmatites.

SUGILITE
Hexagonal
H 5½–6½ • SG 2.7–2.8
This rare, hydrated silicate of potassium, sodium, iron, aluminum, lithium, and manganese occurs in metamorphic rock.

columnar, six-sided prismatic crystal

HELIODOR
Hexagonal
H 7½–8 • SG 2.6–2.8
Named after the Greek for "sun," heliodor is a yellow variety of beryl. Fine examples come from Russia.

rock groundmass

INOSILICATES

ACTINOLITE
Monoclinic
H 5–6 • SG 3.0–3.44
Actinolite is a more iron-rich, darker colored form of the amphibole tremolite. It is one of the asbestos minerals.

TREMOLITE
Monoclinic • H 5–6 • SG 2.9–3.2
A widespread amphibole, this hydrous silicate of calcium, magnesium, and iron forms in metamorphic rocks. It has been used as asbestos.

vitreous luster

radiating crystals

PECTOLITE
Triclinic • H 4½–5 • SG 2.74–2.88
This sodium calcium silicate hydroxide forms in cavities within basalt. It is common in the US, Canada, and England.

NEPHRITE
Monoclinic • H 6½ • SG 2.9–3.4
This very tough, cream to dark green form of the amphiboles tremolite and actinolite is commonly known as jade.

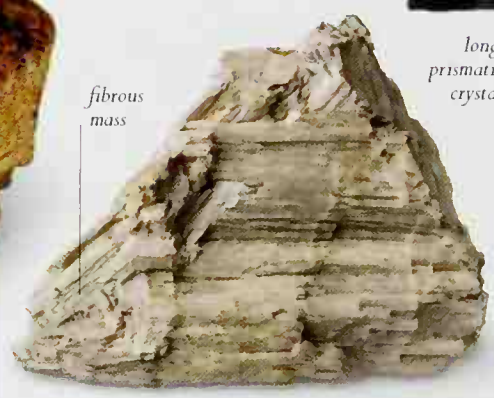
AEGIRINE
Monoclinic • H 6 • SG 3.55–3.60
This brown, green, or black pyroxene is a sodium iron silicate. It forms in metamorphic and dark igneous rocks.

HORNBLENDE
Monoclinic • H 5–6 • SG 3.28–3.41
Common in igneous and metamorphic rocks, dark amphibole or hornblende is a dark, hydrous silicate of calcium, magnesium, iron, and aluminum, with fluorine.

long, prismatic crystal

striated crystal faces

fibrous mass



WOLLASTONITE
Triclinic • H 4½–5 • SG 2.87–3.09
This calcium silicate, found in marble and other metamorphic rocks, is used in ceramics, paints, and as a replacement for asbestos.

RHODONITE
Triclinic
H 5½–6½ • SG 3.57–3.76
Rose-red or pink rhodonite is manganese calcium silicate, occurring as crystals, masses, and grains. It is popularly used in jewelry making.

slender prismatic crystal

prismatic diopside crystal

quartz

SPODUMENE
Monoclinic • H 6½–7½ • SG 3.0–3.2
This pyroxene mineral is a lithium aluminum silicate. Some enormous crystals have been found; the largest weighed almost 100 tons.

DIOPSIDE
Monoclinic • H 5½–6½ • SG 3.22–3.38
This pyroxene is a generally green colored calcium magnesium silicate. It occurs in metamorphic and igneous rocks.

richterite crystal

RICHTERITE
Monoclinic
H 5–6 • SG 2.97–3.13
The amphibole richterite is a hydrous silicate of sodium, calcium magnesium, and iron. It occurs in metamorphosed limestones and igneous rocks.

PIGEONITE
Monoclinic
H 6 • SG 3.2–3.5
This brown to purplish black common pyroxene is a magnesium iron calcium silicate. It occurs in igneous rocks and in meteorites.

AUGITE
Monoclinic
H 5½–6 • SG 3.23–3.52
Augite is the most common pyroxene. This silicate of calcium, sodium, magnesium, iron, titanium, and aluminum occurs in igneous and metamorphic rocks.

ASTROPHYLLITE
Triclinic • H 3 • SG 3.3–3.4
This complex hydrous silicate of potassium, sodium, iron, manganese, and titanium occurs in gneiss and cavities in igneous rocks.

long prismatic crystal

polished jadeite

JADEITE
Monoclinic
H 6–7 • SG 3.24
One of two carving materials commonly referred to as jade, this pyroxene mineral is a sodium aluminum iron silicate.

rock groundmass

long, striated crystals

RIEBECKITE
Monoclinic • H 5 • SG 3.32–3.38
This amphibole is a hydrous sodium iron magnesium silicate, occurring in igneous rocks. The variety crocidolite, or "blue asbestos," occurs in metamorphosed ironstone.

PHYLLOSILICATES

PREHNITE
Orthorhombic
H 6–6½ • SG 2.90–2.95
Prehnite is a hydrous silicate of calcium and aluminum, sometimes used as a gem. It occurs in cavities in basalt.

OKENITE
Triclinic • H 4½–5 • SG 2.3
This hydrated calcium silicate has fibrous or bladelike crystals, usually white or tinted blue or yellow. It occurs in basalt.

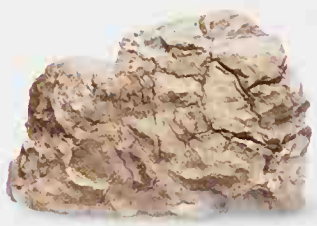
CLINOCHLORE
Monoclinic
H 2–2½ • SG 2.63–2.98
This hydrous silicate of iron, magnesium, and aluminum forms as green tabular crystals. It occurs in a variety of rock types.

MUSCOVITE
Monoclinic
H 2½–4 • SG 2.77–2.88
Muscovite, or common mica, is a potassium aluminum aluminosilicate hydroxide, with fluorine. It is very common in metamorphic rocks and granite.

PHLOGOPITE
Monoclinic
H 2–2½ • SG 2.76–2.90
The colorless, yellow, or brown mica phlogopite is a potassium magnesium aluminosilicate hydroxide.

PETALITE
Monoclinic
H 6–6½ • SG 2.3–2.5
Petalite is a lithium aluminum silicate. Crystals are usually gray-white and in aggregates. It is mined for the lithium.

CAVANSITE
Orthorhombic • H 3–4 • SG 2.2–2.3
Cavansite is a hydrated calcium vanadium silicate. It is blue or greenish blue, and occurs in cavities in basalt.



SEPIOLITE
Orthorhombic • H 2–2½ • SG 2
This pale-colored clay mineral, a hydrated magnesium silicate, usually occurs as earthy masses in altered rocks. It is used for ornamental carving.

LEPIDOLITE
Monoclinic • H 2½–3 • SG 2.8–3.3
Lepidolite is the term used for mica minerals that are potassium lithium aluminum aluminosilicate hydroxides, with fluorine.

TECTOSILICATES

SMOKY QUARTZ
Hexagonal/trigonal • H 7 • SG 2.7
Smoky quartz is a brown variety of quartz, or silicon dioxide. It occurs in igneous rocks and hydrothermal veins.

ROSE QUARTZ
Hexagonal/trigonal • H 7 • SG 2.7
Rose quartz is a prized, translucent pink variety of quartz. Good crystals are rare; more usually it forms massive aggregates.

MILKY QUARTZ
Hexagonal/trigonal
H 7 • SG 2.7
This very common, milky white variety of quartz occurs in all types of rocks and in hydrothermal veins.

CITRINE
Hexagonal/trigonal
H 7 • SG 2.7
Citrine is a yellow to brownish variety of quartz. It resembles topaz and is often used as a gemstone.

AMETHYST
Hexagonal/trigonal
H 7 • SG 2.7
Amethyst is a purple variety of quartz, prized since ancient times. It is found in hydrothermal veins and in lava cavities.

slender crystal

ZINNWALDITE
Monoclinic • H 2½–4 • SG 2.9–3.0
This brown, gray, or green mica is potassium lithium iron aluminum aluminosilicate hydroxide, with fluorine.

CHRYSOCOLLA
Orthorhombic
H 2–4 • SG 2.0–2.4
This blue or greenish blue hydrated silicate of copper and aluminum forms in altered copper deposits. Crystals are rare.

VERMICULITE
Monoclinic
H 1½ • SG 2.3
This green or yellow clay mineral often occurs where micas have been altered. It is a hydrated silicate of magnesium, iron, and aluminum.

GLAUCONITE
Monoclinic • H 2 • SG 2.4–2.95
A mica, glauconite is a potassium sodium magnesium aluminum iron aluminosilicate hydroxide. It occurs in marine sedimentary rocks.

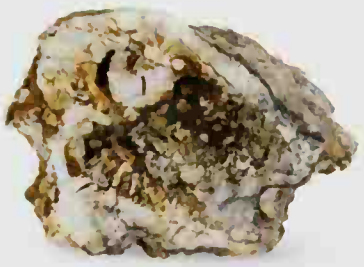
CHRYSOTILE
Monoclinic • H 2½ • SG 2.53
Chrysotile is a hydrous silicate of magnesium, forming fibrous, silky white crystals in serpentinite rock. It is the most abundant of the asbestos form minerals.

tabular biotite crystal

BIOTITE
Monoclinic • H 2½–3 • SG 2.7–3.4
Biotite, or black mica, is a potassium iron magnesium aluminosilicate hydroxide, with fluorine. It is abundant in igneous and metamorphic rocks.

TALC
Triclinic/monoclinic
H 1 • SG 2.58–2.83
The softest of minerals, white, gray, or greenish talc is magnesium silicate hydroxide. Its many uses include toiletries, paint, and ceramics.

PYROPHYLLITE
Triclinic/monoclinic
H 1–2 • SG 2.65–2.90
This aluminum silicate hydroxide, of variable form and color, occurs in low-grade metamorphic rocks. It has good insulating properties.



ALLOPHANE
Amorphous
H 3 • SG 2.8
A clay mineral, this aluminosilicate hydrate is an alteration product of feldspars and other minerals. It forms crusty masses.

vitreous luster

prismatic crystals

ROCK CRYSTAL
Hexagonal/trigonal
H 7 • SG 2.7
Rock crystal is a transparent, colorless variety of quartz, which has been used as a carving material since ancient times.

white quartz vein

JASPER
Hexagonal/trigonal • H 7 • SG 2.7
Jasper is a variety of chalcedony, or microcrystalline quartz, and is used for jewelry. It is opaque, and impurities give a range of colors.

AGATE
Hexagonal/trigonal
H 7 • SG 2.7
Forming in cavities in lavas, agate is a type of chalcedony. It is characterized by concentric color bands caused by impurities.

»

» TECTOSILICATES

OPAL
Amorphous
H 5½–6½ • SG 1.9–2.3
Treasured opal is hydrated silicon dioxide, occurring as nodules, encrustations, or masses in most rock types. Impurities impart a variety of colors.

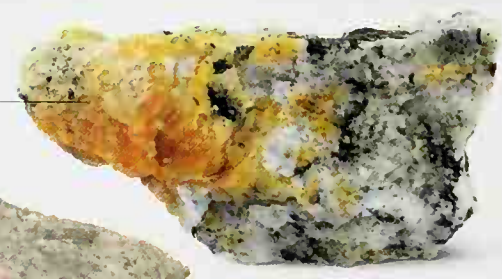
CHALCEDONY
Hexagonal/trigonal
H 7 • SG 2.65
Chalcedony is microcrystalline quartz, or silicon dioxide. Pure chalcedony is white. It forms in veins and cavities of many rock types.

ONYX
Hexagonal/trigonal
H 7 • SG 2.7
Onyx is the striped, semiprecious variety of chalcedony. It is not particularly common; notable locations are India and South America.

CARNELIAN
Hexagonal/trigonal
H 7 • SG 2.7
Carnelian is a variety of chalcedony colored red to orange by iron oxide. The finest quality carnelian comes from India.

BLOODSTONE
Hexagonal/trigonal • H 7 • SG 2.7
Bloodstone is a variety of chalcedony colored dark green by traces of iron silicates. Flecks of red jasper throughout resemble blood.

CHRYSOPRASE
Hexagonal/trigonal • H 7 • SG 2.7
Chrysoprase is a variety of chalcedony containing nickel, which imparts a pale green color. It is the most valuable of the chalcedonies.



CANCRINITE
Hexagonal/trigonal
H 5–6 • SG 2.42–2.51
The feldspathoid cancrinite is a variously colored hydrated sodium calcium aluminosilicate carbonate.

SCAPOLITE
Tetragonal
H 5½–6 • SG 2.50–2.78
The name scapolite encompasses a series of complex sodium calcium silicates, occurring mainly in metamorphic rocks. Scapolites have value as gems.

MICROCLINE
Triclinic
H 6–6½ • SG 2.55–2.63
A very common alkali feldspar, this potassium aluminosilicate is usually white or pinkish. The green variety is called amazonstone.

ANORTHITE
Triclinic
H 6–6½ • SG 2.74–2.76
This uncommon plagioclase feldspar is a calcium aluminosilicate. It forms pale-colored crystals, grains, or masses.

HEULANDITE
Monoclinic
H 3½–4 • SG 2.1–2.2
This zeolite is a hydrated sodium calcium aluminosilicate. It is used in petroleum refining as a molecular sieve.

SCOLECITE
Monoclinic
H 5 • SG 2.27
This zeolite is a hydrated calcium aluminosilicate. Usually colorless or white, it is common in igneous and metamorphic rocks.

ANDESINE
Triclinic
H 6–6½ • SG 2.66–2.68
A plagioclase feldspar, andesine is a gray or white sodium calcium aluminosilicate. It is widespread in igneous rocks.

NATROLITE
Orthorhombic
H 5–5½ • SG 2.20–2.26
One of the most widespread zeolites, this hydrated sodium aluminosilicate occurs in cavities in basalts, and in hydrothermal veins.

HYALOPHANE
Monoclinic
H 6–6½ • SG 2.6–2.8
A relatively rare barium feldspar, this potassium barium aluminosilicate is colorless, white, yellow, or pink.

massive sodalite

SODALITE
Cubic
H 5½–6 • SG 2.14–2.40
The feldspathoid mineral sodalite is a sodium aluminum silicate chloride. Rare crystals have been found in Canada.

STILBITE
Monoclinic
H 3½–4 • SG 2.09–2.20
This widespread zeolite is a hydrated sodium calcium potassium aluminosilicate. It forms sheaflike crystals in a variety of rock types.

HARMOTOME
Monoclinic
H 4½ • SG 2.41–2.50
This widespread zeolite is a pale hydrated barium potassium aluminosilicate. It occurs in hydrothermal veins and volcanic rocks.

ANALCIME
Cubic
H 5–5½ • SG 2.22–2.29
This pale zeolite, a hydrated sodium aluminosilicate, occurs in igneous, metamorphic, and some sedimentary rocks.

long, slender, needlelike crystals

lazurite crystal

calcite matrix

ALBITE
Triclinic
H 6–6½ • SG 2.60–2.63
Considered an alkali and plagioclase feldspar, albite is a pale-colored sodium aluminosilicate. It is an abundant mineral.

ANORTHOCLASE
Triclinic
H 6–6½ • SG 2.56–2.62
An alkali feldspar, anorthoclase is a sodium potassium aluminosilicate occurring as prismatic or tabular crystals.

LAZURITE
Cubic
H 5–5½ • SG 2.4–2.5
The intense blue feldspathoid mineral lazurite is a sodium calcium aluminosilicate sulfate. It is the main mineral in lapis lazuli gems.

THOMSONITE
Orthorhombic
H 5–5½ • SG 2.25–2.40
A pale-colored zeolite, thomsonite is a hydrated aluminosilicate of sodium and calcium, widespread in cavities in basalts.

LAUMONTITE
Monoclinic
H 3–4 • SG 2.2–2.4
A widespread and common zeolite, laumontite is a hydrated calcium aluminosilicate. It occurs in igneous, metamorphic, and sedimentary rocks.

short, prismatic orthoclase crystal

POLLUCITE
Cubic
H 6½–7 • SG 2.7–3.0
A rare zeolite, this complex hydrated aluminosilicate of cesium and sodium commonly has other elements in it (e.g. calcium). It is a source of cesium.

ORTHOCLASE
Monoclinic • H 6–6½ • SG 2.55–2.63
Orthoclase alkali feldspar is a potassium aluminosilicate. It is a major component of many igneous and metamorphic rocks.

CHABAZITE
Hexagonal/trigonal
H 4–5 • SG 2.05–2.16
This common zeolite is a hydrated sodium calcium aluminosilicate. Crystals are colorless, white, yellow, or pink.

hairlike tufts of mesolite crystals

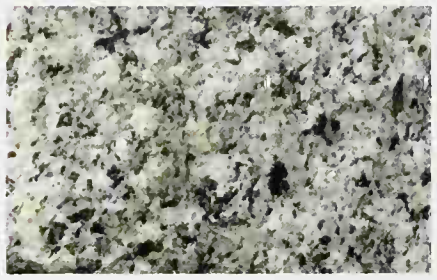
MESOLITE
Monoclinic • H 5 • SG 2.2–2.3
This white or colorless zeolite occurs in igneous and metamorphic rocks. It is a hydrated sodium calcium aluminosilicate.

HAÜYNE
Cubic • H 5½–6 • SG 2.5
A feldspathoid mineral, haüyne is a sodium calcium aluminosilicate, with sulfate and chlorine. It occurs mainly in silica-deficient volcanic rocks.

pseudocubic (almost cubic) rhombohedral crystal

ROCKS

Made of different mixtures of minerals, rocks form Earth's solid crust. The epitome of strength and solidity, they are actually in a state of constant change, with rock being destroyed and reformed over immense periods of time. Rocks are classified into three main groups, depending on how they form.



Igneous rocks can be formed by the cooling of magma deep underground, like this granite, or by volcanic eruption.

Sedimentary rocks such as red chalk are formed by the erosion of existing rocks and the recrystallization of their minerals.

Metamorphic rocks such as muscovite schist occur when changes in pressure, temperature, or both alter the mineralogy.

The world's oldest known rocks, from Canada's Northwest Territories, have existed for about four billion years. But most rocks are far younger than this. The chalk cliffs facing the English Channel date back to the Cretaceous Period, which ended 65 million years ago (see timeline, below), and the European Alps are younger still. Even in the Grand Canyon, the oldest rocks date back two billion years—less than half the lifetime of the planet as a whole. The reason for this is that Earth is tectonically active, with new rock being formed by the planet's internal heat. At the same time, existing rocks are broken down, in a endless cycle that started when Earth's crust first formed.

ROCK GROUPS

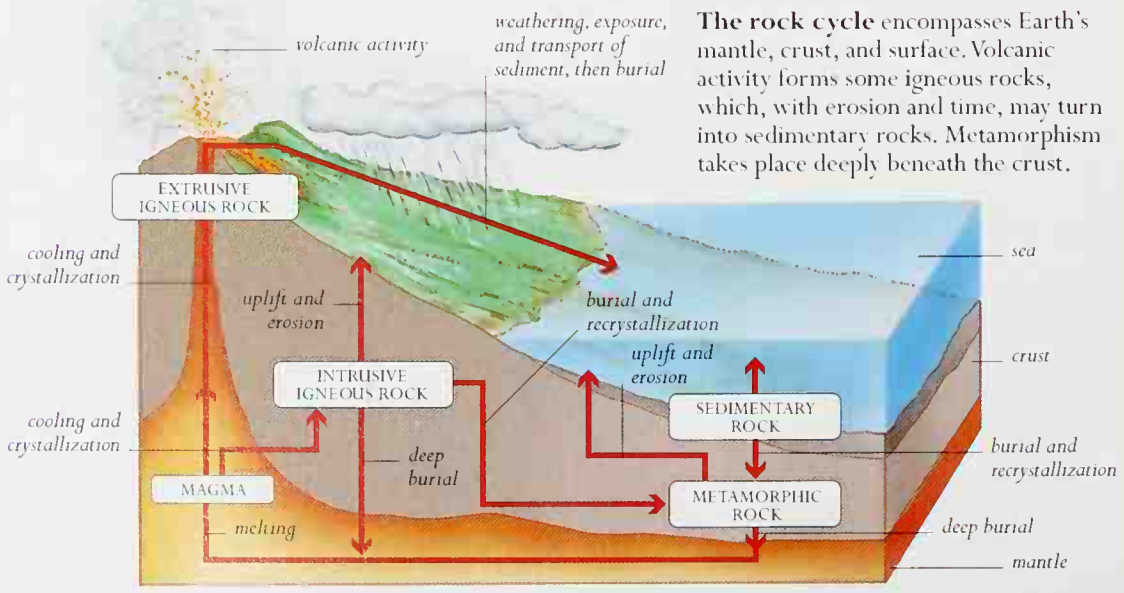
Rocks are classified into three overall groups—igneous, sedimentary, or metamorphic—reflecting the different ways in which they are formed. Igneous rock is created by volcanic heat, from molten magma in the Earth's mantle. The most common kind, a black crystalline rock called basalt, is produced by volcanic eruptions on Earth's surface. Basalt forms most of the seafloor. Volcanism can also create plutonic rock, which cools and solidifies beneath the surface in huge masses called batholiths. This is how most of the world's granite originates.

Sedimentary rocks form on Earth's surface. Their key feature is their layers, or strata, built up over long periods of time. Some sedimentary rocks—such as sandstone and shale—form when existing rocks erode, releasing particles that are then washed or blown away, forming rock elsewhere. Others, such as rock salt and rock gypsum, are created when saltwater evaporates, leaving behind its dissolved minerals, known as evaporite deposits. Sedimentary rock can also have a biological origin: chalk and limestone are formed from the microscopic skeletons of marine organisms, whereas coal is derived from the remains of plants, compressed over millions of years.

Metamorphism takes place deep beneath Earth's surface, when rocks are altered by heat, pressure, or both. For example, marble is created when limestone is heated by lava or by magma. Unlike limestone, marble is unlayered, and its fine texture enables it to be cut without splitting apart—a quality prized in sculpture. But if metamorphism is intense enough, rock turns back into molten magma. This completes the last link in the cycle, as solid rock is finally destroyed.

GRAND CANYON, COLORADO >
This view of the Grand Canyon shows the almost horizontal layering of sedimentary rocks and the effects of river erosion.

ROCK CYCLE



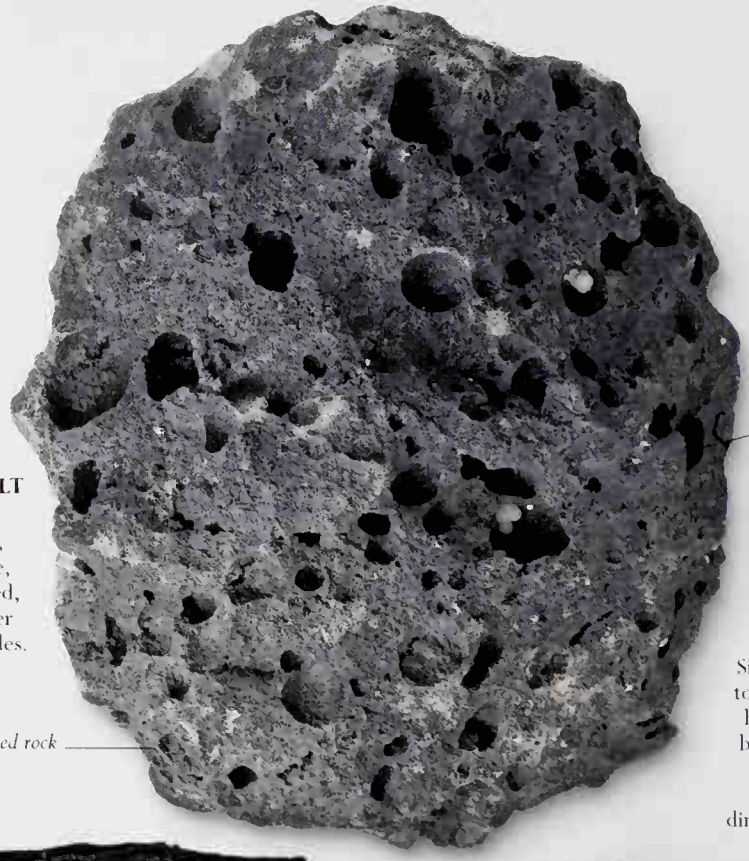
The rock cycle encompasses Earth's mantle, crust, and surface. Volcanic activity forms some igneous rocks, which, with erosion and time, may turn into sedimentary rocks. Metamorphism takes place deeply beneath the crust.

GEOLOGICAL TIMELINE

Era	Period from modern to Precambrian strata	Epoch	Start (mya)
Cenozoic	Quarternary	Holocene	0.01
		Pleistocene	1.8
	Neogene	Pliocene	5.3
		Miocene	23
	Paleogene	Oligocene	34
		Eocene	55
		Paleocene	65
Mesozoic	Cretaceous		145
	Jurassic		199
	Triassic		251
Paleozoic	Permian		299
	Carboniferous (split into Lower Mississippian and Upper Pennsylvanian in USA)		359
	Devonian		416
	Silurian		433
	Ordovician		488
	Cambrian		542
Precambrian	Formation of the Earth		4,554

IGNEOUS ROCKS

Rocks that solidify from a molten state are called igneous and are broadly divided into extrusive (volcanic) rocks and intrusive rocks. Extrusive rocks form from lava on the Earth's surface, while intrusive rocks form underground, from magma. Lava and magma are rich in silica and metallic elements. As they cool, minerals such as feldspars form, along with quartz. Different combinations of these minerals make up many of the igneous rocks.



RHYOLITE

This fine-grained, pale-colored lava contains much quartz, mica, and feldspar. Often banded, it frequently includes visible phenocrysts (larger crystals).

BASALT

A dark, fine-grained volcanic rock, basalt is the most common rock forming the oceanic crust.

VESICULAR BASALT

Dominated by the minerals plagioclase, pyroxene, and olivine, this lava is dark-colored, with numerous former gas cavities called vesicles.

BANDED RHYOLITE

Similar in composition to granite, rhyolite also has tiny glass crystals because it forms from rapidly cooled lava. Banding shows the direction of magma flow.

AMYGDALOIDAL BASALT

Amygdaloidal means almond-shaped and refers to the gas bubbles found in basaltic lavas, which are typically infilled with secondary minerals such as zeolite, carbonate, and agate.

PAHOEHOE

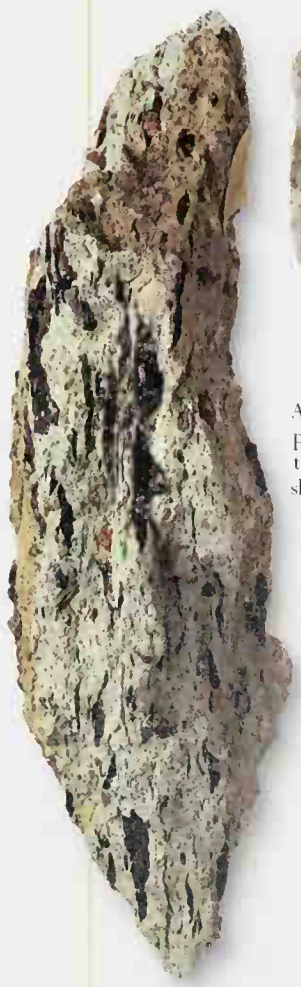
Common in Hawaii, pahoehoe is named after the Hawaiian word *hoe*, meaning "to swirl." This refers to the ropy-textured, glassy surface of this basaltic lava.

PORPHYRITIC BASALT

This dark-colored rock has large crystals, typically of olivine or plagioclase, set in a fine-grained matrix.

PUMICE

Formed from frothy lava, pumice contains small crystals of feldspar in a glassy matrix. It is pale-colored and so highly porous that it floats.



IGNIMBRITE

A fine-grained, glassy, pale-colored volcanic tuff, ignimbrite often shows banding caused by the flow of lava when molten.

LITHIC TUFF

This rock contains fragments of previously formed rock in a fine, glassy matrix. Usually pale, lithic tuff is formed by violent volcanic eruptions.

SPINDLE BOMB

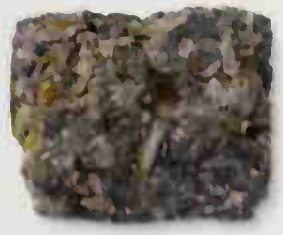
Molten, low-viscosity basaltic magma blasted through the air can assume aerodynamic forms such as this one. Such masses cool on the surface to form "bombs."

BREADCRUST BOMB

This variety of volcanic bomb is characterized by a cracked crust, due to continued expansion of the interior after the exterior has solidified.

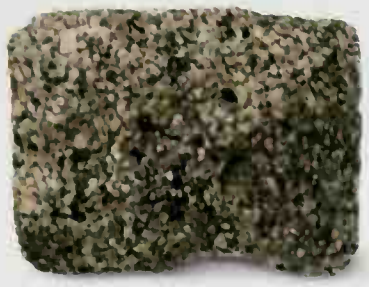
AGGLOMERATE
Composed of relatively large rock fragments set in a finer matrix, agglomerate forms after volcanic explosions.

PITCHSTONE
This glassy, dense volcanic rock has variable composition and color, and a pitchlike, waxy, resinous sheen.



PORPHYRITIC ANDESITE
Commonly composed of plagioclase feldspar, pyroxene, and amphibole, porphyritic andesite contains large crystals set in its fine-grained matrix.

ANDESITE
Named after the Andes mountains, andesite is common in many of the world's subduction related volcanic arcs—chains of islands or mountains formed by plate movement. It is typically about 60 percent silica by weight.



DACITE
A light- to medium-colored rock with fine to coarse grains, dacite is mainly made of plagioclase feldspar and quartz, with pyroxene, biotite mica, and hornblende.

AMYGDALOIDAL ANDESITE
Brown, mold, purple, or red, this is a fine-grained volcanic rock containing infilled gas bubbles called amygdales.

PORPHYRITIC TRACHYTE
This rock has a complex mineralogy of alkali feldspar, quartz, mica, pyroxene, and hornblende. Its matrix has large crystals.

TRACHYTE
Trachyte is a fine-grained volcanic group of rocks containing alkali feldspar and dark-colored mafic minerals such as biotite, hornblende, and pyroxene. These rocks are usually rough to the touch.

SPILITE
This fine-grained, brownish, altered volcanic rock contains augite and plagioclase feldspar. It forms by alteration of basalt lava in contact with sea water.

RHOMB PORPHYRY
This igneous rock is characterized by large crystals of feldspar with a rhomb-shaped cross section set in its dark matrix.

curved fracture

pale patch of devitrified glass

OBSIDIAN
Typically very dark, obsidian is formed by rapid cooling of highly viscous, hot, rhyolitic lava before individual minerals have had time to form crystals. This gives it a glassy texture. Obsidian has been used in jewelry since ancient times.

SNOWFLAKE OBSIDIAN
The "snowflakes" in this glassy, black volcanic rock, with a high silica content, are areas where minerals have crystallized from the glass.

patch of red garnet

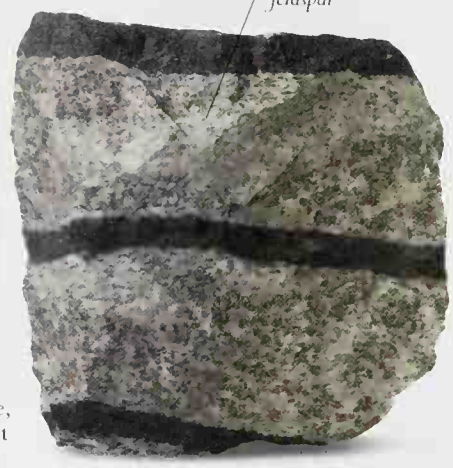
GARNET PERIDOTITE
Peridotite is the main rock of the Earth's upper mantle. This dense, greenish variety is made of dark minerals including garnet, olivine, clinopyroxene, and orthopyroxene.

»

» IGNEOUS ROCKS

GABBRO

This dark, plutonic rock contains plagioclase, pyroxene, and olivine. Coarse-grained, it forms from the slow cooling of basaltic magma at depth.

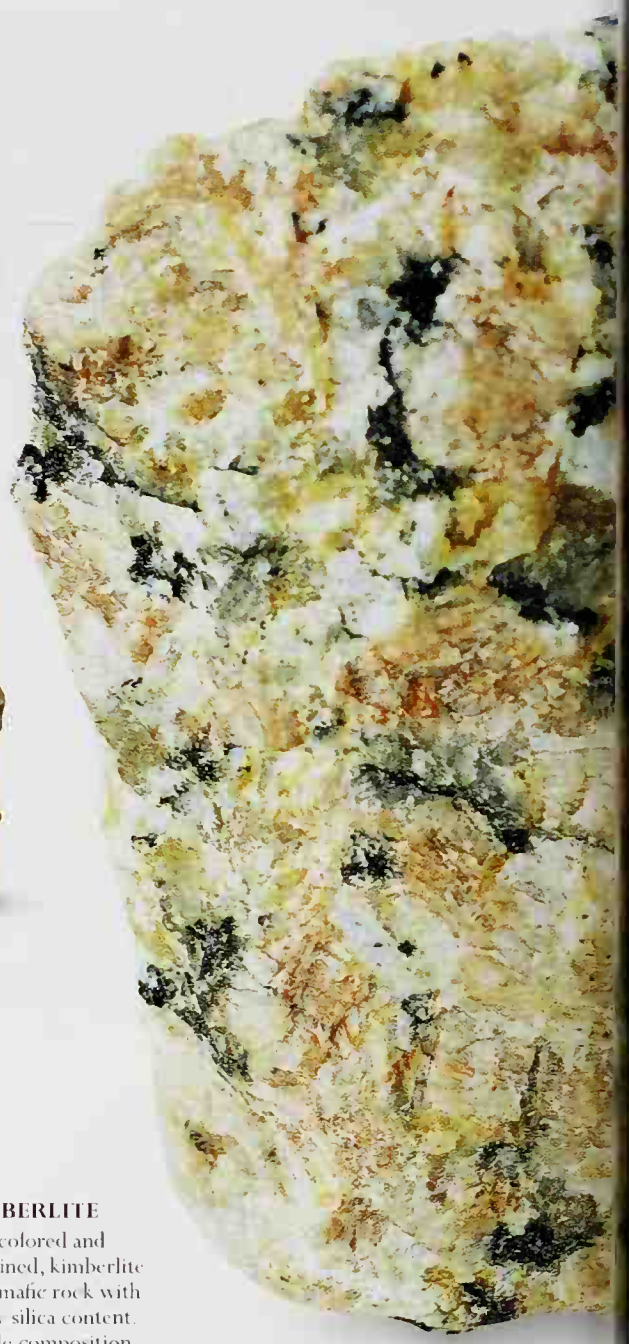


OLIVINE GABBRO

Gabbro is a dark, coarse-grained rock with a lot of pyroxene and plagioclase. Olivine occurs in significant amounts in this variety.

LAYERED GABBRO

Coarse-grained and dark-colored, this type of gabbro shows banding caused by the settling of minerals of different density in the magma.



PINK MICROGRANITE

MICROGRANITE

This granite—with fine to very fine grains, often with a porphyritic texture—occurs in sills and dykes, which are sheets of intrusive igneous rock.

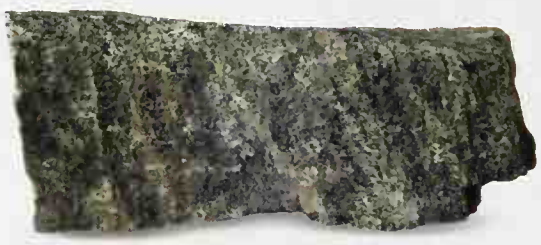
WHITE MICROGRANITE

PORPHYRITIC GRANITE

Large crystals are set into the matrix of this medium-grained rock, which is composed mainly of quartz, mica, and feldspar.

KIMBERLITE

Dark-colored and coarse-grained, kimberlite is an ultramafic rock with a very low silica content. Of variable composition, it is the world's main source of diamonds.



BOJITE

A dark-colored igneous rock, bojite is a general term for a hornblende gabbro. It is coarse-grained and forms from magma.

GRANODIORITE

This is the most common intrusive igneous rock in the continental crust. It is over 65 percent plagioclase.

PEGMATITE

Pegmatites are very coarse-grained rocks, formed from residual liquid magma after most of a granite intrusion has cooled and crystallized. Some pegmatites are an important source of gemstones.

NEPHELINE SYENITE

Coarse-grained, pale-colored, and composed of feldspar, mica, and hornblende, this rock also contains nepheline but no quartz.

LAMPROPHYRE

Lamprophyre's matrix is fine-grained and studded with distinct crystals of the water-bearing minerals mica and amphibole. It has a glistening texture.

SYENITE

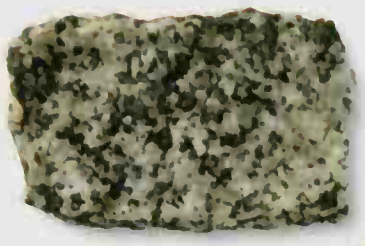
Gray or pinkish, syenite is a plutonic rock that occurs in large intrusions. Coarse-grained, it has feldspar, mica, and hornblende, and little or no quartz.

GRANITE

Coarse-grained and of varying color, granite contains more than 10 percent quartz. Typically a tough rock, resistant to erosion, it is often used in building.

GRAPHIC GRANITE

This coarse-grained rock contains quartz and feldspar, whose intergrowth results in a graphic texture, vaguely resembling runic writing. It also contains mica.



HORNBLENDE GRANITE

Granite typically contains quartz, feldspar, and mica. This variety also contains hornblende, a member of the amphibole mineral group.

PORPHYRITIC GRANITE

A pale-colored rock composed of feldspar, quartz, and mica, porphyritic granite has large, well-formed crystals set into the matrix.

DOLERITE

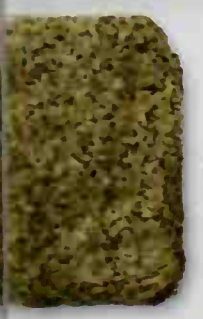
Typically occurring in sills and dykes, dolerite is a dark, medium-grained rock composed of plagioclase, pyroxene, and iron oxides.

FELSITE

Fine-grained felsite forms as sheetlike intrusions in sills and dykes. Pale-colored, it is composed mainly of feldspar and quartz.

DUNITE

Composed only of olivine, this rock is dark green or brown, with a sugary texture. It usually includes a little chromite.



ADAMELLITE

This medium-grained granite forms at depth with crystals of quartz, mica, and feldspar. One-third to two-thirds of the total feldspar is plagioclase.

ANORTHOSITE

Pale-colored, anorthosite is composed mainly of large crystals of plagioclase feldspar. It can also contain olivine and augite.

PERIDOTITE

A dark, dense rock composed mainly of olivine and pyroxene, peridotite is coarse-grained and forms slowly at great depth.

LARVIKITE

A form of syenite, larvikite is blue-black and made of large amounts of sodic feldspar that can have a glittering blue schiller effect.

DIORITE

Composed of plagioclase feldspar, with amphibole and pyroxene, diorite contains little or no quartz. It was used for ornamental purposes in ancient Egypt.

METAMORPHIC ROCKS

When existing rocks are subjected to heat or pressure or both within the Earth, they are transformed into different assemblages of minerals. Contact metamorphism occurs when intense, localized heat radiated by a body of igneous rocks causes the surrounding rocks to recrystallize. Regional metamorphism takes place over wide areas, at considerable depth, as a result of intense heat and pressure. The Earth's movements can result in rocks being pulverized by dynamic metamorphism.

GRANULITE

Formed at very high temperatures and pressures, granulite is dark, coarse-grained, and rich in pyroxene, garnet, mica, and feldspar.

GARNET SCHIST

The red garnets in this variety of schist indicate that it developed at relatively high temperatures and pressures deep within the continental crust.

CRENULATED SCHIST

Schist is characterized by its parallel planes of similarly oriented minerals within the rock. This corrugated pattern is called crenulation.

MYLONITE

When rocks are pulverized deep within a fault zone, the rock dust and fragments produced form a fine-grained rock called mylonite.

SLATE

Dark and very fine-grained, slate is a compact rock with parallel cleavage planes. It is formed by low-pressure metamorphism.

KYANITE SCHIST

Mainly composed of feldspar, mica, and quartz, this schist also contains crystals of the blue mineral kyanite.

MUSCOVITE SCHIST

A typical schist with pale, glittery muscovite mica, this rock also contains quartz and feldspar.

HALLEFLINTA

Originally volcanic tuff, rhyolite, or quartz porphyry, halleflinta is fine-grained, pale-colored, and rich in quartz. It is a type of hornfels.

SPOTTED SLATE

This is a dark, fine-grained rock characterized by black spots (porphyroblasts) of minerals, such as cordierite and andalusite.

BIOTITE SCHIST

Formed at relatively high pressures and temperatures, biotite schist contains feldspar, quartz, and a lot of biotite mica, which makes it dark.

MIGMATITE

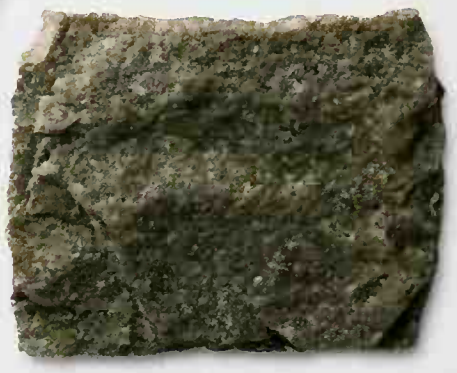
Formed at the highest temperatures and pressures, coarse-grained, folded migmatite contains bands of dark basaltic minerals and pale granitic minerals.

FULGURITE

When lightning strikes in deserts or on beaches, sand melts into small, tube-shaped structures. These structures are called sand fulgurites.

SKARN

Formed when carbonate rocks are altered by high-temperature contact metamorphism, skarn contains minerals rich in calcium, magnesium, and iron.



QUARTZITE

With a high percentage of quartz, this rock is harder than most metamorphic rocks. It is formed from sandstone altered at high temperature.

CHIASTOLITE HORNFELS

Hornfels forms at very high temperatures near magma intrusions. Bladed crystals of pale chiastolite give this particular variety its name.

CORDIERITE HORNFELS

Dark and splintery, cordierite hornfels forms from the heat of nearby igneous intrusions. It is fine- to medium-grained.

PYROXENE HORNFELS

Fine- to medium-grained, tough, and flinty, this variety of hornfels contains quartz, mica, and pyroxene. It forms next to igneous intrusions.

GARNET HORNFELS

Hornfels is a tough, dark, flinty rock formed by heat next to an igneous intrusion. Reddish garnets occur in this particular variety.

GNEISS

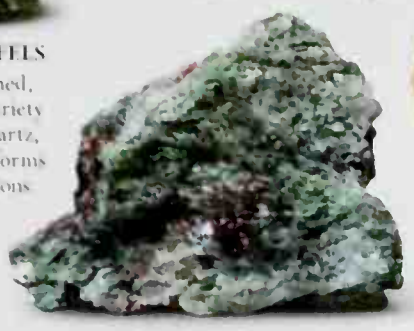
A medium- to coarse-grained rock formed at very high temperatures and pressures, gneiss is recognized by its alternating dark and light crystalline layers.

AUGEN GNEISS

Gneiss contains quartz, feldspar, and mica, often in parallel bands. Augen gneiss has crystals resembling lens-shaped eyes (*augen* in German).

FOLDED GNEISS

Gneiss becomes plastic and folded at great depth. The dark bands are hornblende-rich and the paler ones are quartz and feldspar.



ECLOGITE

Made of two main minerals, green omphacite pyroxene and red garnet, eclogite is coarse-grained and forms at very high temperatures and pressures.

AMPHIBOLITE

Formed by moderate heat and varying pressure deep in the crust, this coarse-grained rock has an abundance of hornblende and plagioclase, as well as other minerals.

PHYLLITE

Phyllite is formed at lower temperatures and pressures than schist, but higher than slate. It is fine-grained and splits into slabs with a characteristic sheen.

GRANULAR GNEISS

This gneiss has a granular texture with equal-sized grains. It has dark bands of hornblende and biotite, and pale bands of quartz and feldspar.

MARBLE BRECCIA

GRAY MARBLE

MARBLE

Formed by contact or regional metamorphism, marble is rich in calcite, often with colorful veins of other minerals. It is prized as a carving material.

GREEN MARBLE

SERPENTINITE

Commonly banded, blotched, or streaked, serpentinite is a dense, but soft, metamorphic rock derived from peridotite. It is found in convergence zones between tectonic plates.

SEDIMENTARY ROCKS

These rocks result from deposition of sediment laid down by wind, water, and ice on the Earth's surface, and its subsequent burial. Sedimentary rocks are characterized by stratification or bedding, and they can contain fossils. They are broadly divided into clastic rocks—made up of fragments of rock and subdivided by grain size—and chemical and biochemical rocks, which are grouped according to their chemistry.

MILLET-SEED SANDSTONE
This rock is medium-grained, with a reddish iron oxide coating. Its well-rounded, equal-sized quartz grains have been shaped by the wind.

GREENSAND
Colored greenish by the silicate mineral glauconite, greensand is a quartz-rich sandstone formed in the ocean.

RED SANDSTONE

MICACEOUS SANDSTONE
Rich in quartz, this sandstone also contains glittery flakes of mica. It usually has medium-sized grains.

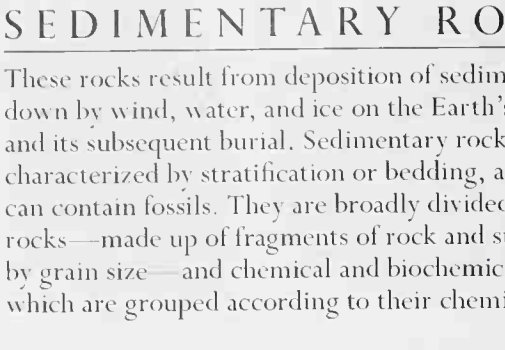
LIMONITIC SANDSTONE
This rock is colored red-brown or yellowish by the iron oxide mineral limonite, which coats its medium to fine quartz grains.

ROCK SALT
Formed of crystalline halite, rock salt is brownish and may contain clay. It is soluble and soft, and has a distinct taste.

ROCK GYPSUM
A crystalline rock associated with potash rock and created when salt water evaporates, rock gypsum is pale-colored, often fibrous, and very soft and soluble.

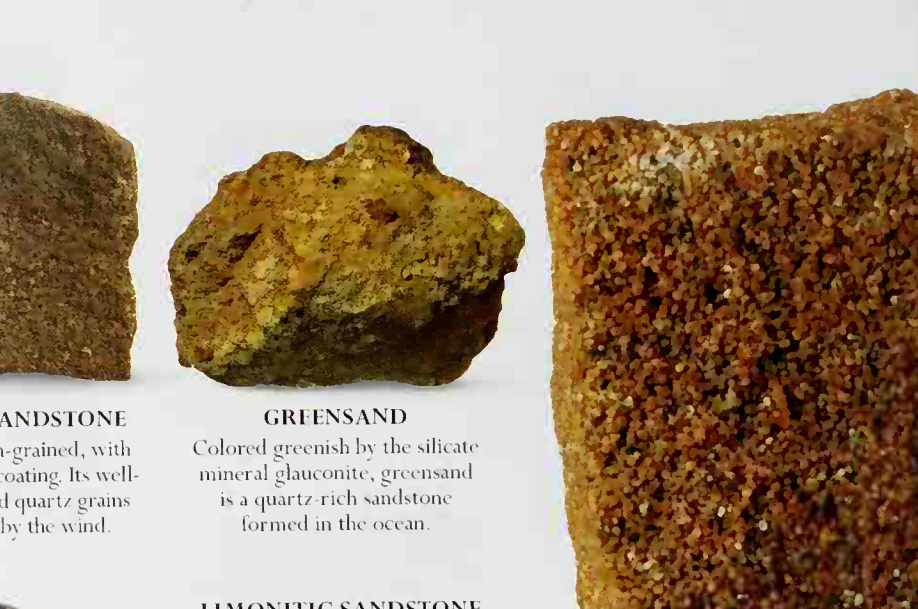
SANDSTONE

SANDSTONE
This typically occurs as stratified layers of sand-sized particles, held together by various mineral cements that impart different colors. Most are quartz-rich.



BOULDER CLAY
Gray or brownish colored, boulder clay or till has a fine clay matrix filled with angular and rounded rock fragments.

CLAYSTONE
Of varying color, this very fine-grained rock is composed mainly of silicate clay minerals such as kaolinite—mostly derived from the weathering of feldspar.



TRAVERTINE
A pale-colored and often layered rock, travertine is virtually pure calcite. It is formed around hot springs and volcanic vents.

BANDED IRON FORMATION
This marine deposit has alternating bands of black hematite and red chert. It is one of the best ores of iron.

OOLITIC IRONSTONE
This rock is composed of small, rounded sedimentary grains (ooliths) of iron minerals, such as siderite, cemented by other iron minerals, as well as calcite and quartz.

LOESS
A clay with very fine, dustlike grains lifted by the wind from dry land surfaces, loess is crumbly and lacks obvious layering.

TUFA

This porous rock is formed by the precipitation of carbonate minerals from ambient temperature bodies of water, such as hot springs.

GRAY ORTHOQUARTZITE

ORTHOQUARTZITE

Rarely containing fossils, this rock is composed almost entirely of silica cemented quartz grains. Orthoquartzite is also known as quartz arenite.

PINK ORTHOQUARTZITE

MANGANESE NODULE

Rich in valuable transition metals such as copper, manganese nodules are rounded, black concretions that form on the deep ocean floor.

rounded nodule

LIGNITE

JET

LIGNITE

Lignite is brown coal with a lower carbon content than bituminous coal. Jet is a hard, black, lustrous form of lignite, and will take a high polish.

ANTHRACITE

The purest form of coal, anthracite is black and shiny, with a vitreous surface. It has curved edges when broken.

BITUMINOUS COAL

This sedimentary rock has a lower carbon content than anthracite. Brittle and dull, it is the most abundant type of coal.

internal radiating structure

pale calcite filling cracks (septa)

SEPTARIAN NODULE

This type of concretion occurs in sedimentary rocks as individual, rounded masses, cemented by quartz or calcite. Internally they have septa (from the Latin *septum*, meaning "barrier").

PYRITE NODULE

Gray or black internally and brassy yellow outside, these nodules occur in shale and clay, and are composed entirely of pyrite.

»

» SEDIMENTARY ROCKS

NUMMULITIC LIMESTONE
A marine bryozoan, *Nummulites* is the main fossil in this rock. The cement is calcite, originally lime mud.

CRINOIDAL LIMESTONE
Crinoids are echinoderms that are attached to the seabed by a flexible stem. Crinoidal limestone is a mass of broken stems cemented by hardened lime mud.

FRESHWATER LIMESTONE
This limestone is a pale, calcite-rich rock with some quartz and clay. It contains fossils of freshwater-dwelling organisms, which indicate where the rock formed.

PISOLITIC LIMESTONE
This rock is made of pisoliths—pea-sized grains slightly larger than ooliths, often flattened, and loosely cemented by calcite.

CORAL LIMESTONE
This rock is a mass of fossilized corals cemented by fine-grained calcite. It is gray to white or brownish.

OOLITIC LIMESTONE
This limestone is composed of ooliths—small, rounded, concentrically banded sedimentary grains rolled by seabed currents and cemented by carbonate mud.

BRYOZOAN LIMESTONE
This is a gray or reddish organic limestone, which has fossils of bryozoans in a matrix of hardened, calcite-rich mud.

LIMESTONE BRECCIA
Large, angular rock and quartz fragments cemented by calcite are typical of this rock, which forms at the base of cliffs.

FELDSPATHIC GRITSTONE
Coarse-grained and pale- to dark-colored, this gritstone contains a lot of quartz and up to 25 percent feldspar.

QUARTZ GRITSTONE
This gritstone is made of quartz with some feldspar and mica, all of coarse grain size.

GRAYWACKE
This dark rock contains quartz, rock fragments, and feldspar, set in a mass of finer clay and chlorite. It forms in marine basins.

ARKOSE
Variable in color and medium- to coarse-grained, arkose is a sandstone with a high percentage of feldspar.

DOLOMITE
Often cream- or buff-colored, this rock contains a high percentage of dolomite (calcium magnesium carbonate). It is also called dolostone, to distinguish it from the mineral.

FOSSILIFEROUS SHALE
Fine-grained marine sedimentary rocks such as shale often contain large numbers of well-preserved fossils.

SHALE
This fine-grained, layered rock varies in composition, usually containing silt, clay minerals, organic materials, iron oxides, and minute crystals of minerals such as pyrite and gypsum.

POLYGENETIC CONGLOMERATE

The coarsest-grained sedimentary rock, polygenetic conglomerate has many different, rounded rock and mineral fragments in a fine matrix.

rounded quartz pebble

sandstone matrix

fine-grained matrix

iron oxide gives red color

QUARTZ CONGLOMERATE

Varying in color, this rock typically has dirty white, pebble-sized quartz fragments set in a finer, darker matrix.

RED CHALK

CHALK

Pure calcite, chalk is fine-grained, powdery, and easily crumbled. It is made of minute fossilized organisms, including coccoliths and radiolarians.

WHITE CHALK

SILTSTONE

This dark-colored rock has particles smaller than fine sand, but larger than clay grains—mainly of quartz. It also has organic material and calcite.

BRECCIA

This rock has large, angular fragments of rocks and minerals set in a fine matrix of sand or silt. It rarely forms in layers.

MARL

Midway between clay and limestone in hardness, marl is a fine-grained, calcite-rich, layered rock. Chlorite and glauconite may give it a green color.

MUDSTONE

With a lot of clay and very fine quartz and feldspar fragments, mudstone differs from shale in that it forms as a block, with no layering.

CHERT

A very fine-grained form of silica, chert occurs as bands and nodules in rocks such as limestone. It has many colors; red chert is called jasper.

FLINT

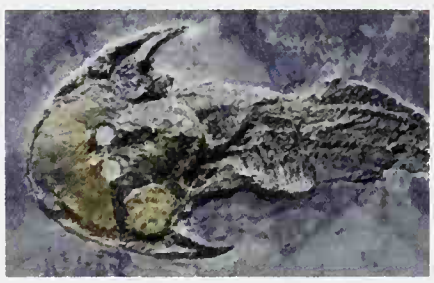
Usually found as nodules in chalk, flint is very hard, black, compact silica. It breaks leaving sharp, curved edges.

FOSSILS

Fossils are evidence of past life that has been buried and preserved in the rocks of Earth's crust. They give scientists important clues about how life has evolved, and they can also be used to date rocks, and create a timeline of the events that have shaped our world.

Over time the tissues of this plant have turned to charcoal. Only the outline remains, covered by a thin film of carbon.

An insect became stuck on resin oozing from a tree. The resin turned into amber, perfectly preserving the creature.



This fish skeleton has been fossilized in shale. Here all the atoms of the original skeleton have been chemically replaced.

Life has existed on Earth for about 3.8 billion years. Initially, living things were small and soft-bodied, and left few obvious traces of their existence. But during the past billion years, life gradually changed. Organisms evolved hard body parts, which—given enough time—could fossilize. The significance of this change is hard to overstate. It turned the world's sedimentary rocks into a global data bank, teeming with an incredible array of fossilized species, arranged in the exact order in which they appeared. These fossils show the path evolution has followed. They also highlight mass extinctions, when enormous numbers of species have been wiped out in a relatively short space of time.

DEAD AND BURIED

Fossilization is a lottery, and only a small fraction of living organisms end up being preserved. On land, it is usually triggered by chance events—for example, when animals are overwhelmed by landslides or flash floods, or when they drown in lakes. Marine animals have a much better chance of being fossilized, because sediment routinely accumulates over their dead remains. Fine sediment can preserve soft bodies, but the best fossils are left by animals with hard body parts, such as shells or bones. After burial, the remains are slowly infiltrated by dissolved minerals, which literally turns them to stone. Once formed, many fossils are destroyed by heat, pressure, or geological movements while still deep underground. But if a fossil survives all this, uplift may eventually bring it back to the surface, where erosion can release it from its parent rock (see panel, below). There, it has to be found before it eventually breaks apart.

These body fossils can be breathtaking objects, particularly when they are complete skeletons several yards long. However, they are not the only kind of fossilized remains. Rocks can also yield trace fossils, which are fossilized footprints, burrows, or other signs of animal activity. Trace fossils provide indirect but fascinating evidence of how animals lived: for example, dinosaur footprints can show how fast they moved, how they interacted in herds, and even how they put on weight as they grew.

Much further back in time, rocks sometimes contain chemical fossils—ancient carbon-based compounds that have been produced by biological processes. Although unspectacular, these chemical smudges are key evidence in the hunt for Earth's earliest living things.

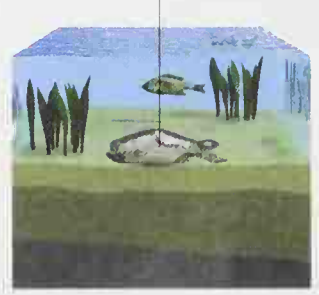
SUDDEN DEATH >
Here, many trilobites of Ordovician age are fossilized together, suggesting the sudden burial of these animals by sediment.

DEBATE

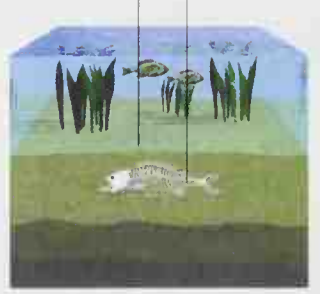
INDEX FOSSILS

The geological timescale was largely established using fossils. Species which lived across a wide geographical range but only existed for a short time, are known as index fossils. They can be used to identify particular strata and link them from place to place—the presence of the same index fossil in different places shows that the strata were laid down at the same time. Index fossils therefore help geologists to date rocks and build a relative time sequence. Mesozoic ammonites (a group of extinct marine mollusks) are among the best index fossils—an ammonite zone may be as little as a million years.

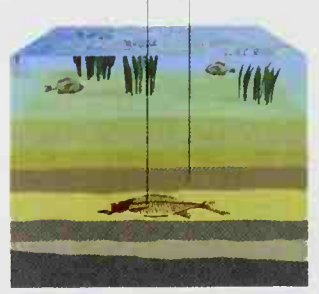
HOW FOSSILS FORM



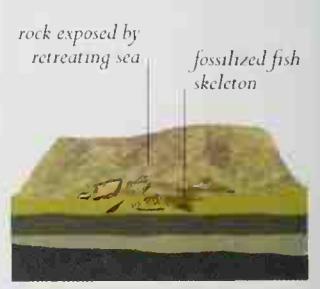
A dead fish lies on the seabed, where its flesh may rot or be eaten. It must be buried rapidly to be preserved. As the mud turns into shale, it will compress and flatten the body.



The fish skeleton has been covered by sediment. To become fossilized, the bones must undergo chemical changes, driven by heat and pressure, which replace the bone with other minerals.



More sediment has accumulated on the seabed and compressed the lower layers. The composition of the bones changes further as they are enclosed between the layers of sediment.



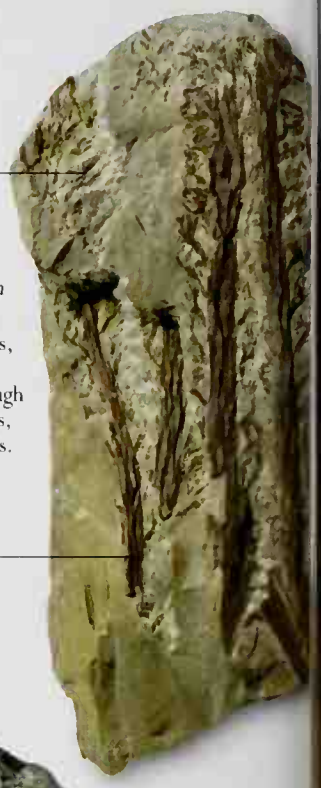
Millions of years later the seabed sediment, now turned to rock, has been exposed by retreating seas. Weathering has further denuded the rock around the fossilized fish skeleton.

FOSSIL PLANTS

Plants are among the first organisms to appear in the fossil record. Algae are found in rocks from the Precambrian. Vascular plants (plants with tissues for conducting water and nutrients) evolved in the Silurian Period, and by Carboniferous times, Earth was colored green by vast, coal-forming swamp forests. Flowering plants developed later, in the Mesozoic Era.

EARLY LAND PLANT
Cooksonio hemisphoerico
Found in Silurian and Devonian rocks, *Cooksonia* was one of the earliest vascular plants. It had a stiff stem and leafless branches.

CALAMOPHYTON STEMS
Calamophyton primaevum
A primitive, leafless plant, probably related to ferns, *Calamophyton* is found in Devonian and Early Carboniferous rocks.



CLADOXYLON STEMS
Clodoxylon scoporium
Fossilized in Devonian and Carboniferous rocks, *Cladoxylon* was a low-growing plant, with a tough central stem and leafless, light-absorbing branches.

SEED FERN LEAF
Alethopteris serlii
A seed fern from Carboniferous and Permian strata, *Alethopteris* had compound pinnate fronds, consisting of thick, strongly veined leaflets.

CYCLOPTERIS LEAFLETS
Cyclopteris orbicularis
Oval leaflets from the seed fern *Neuropteris* are given the scientific name *Cyclopteris*. Its fossils belong to Carboniferous strata.

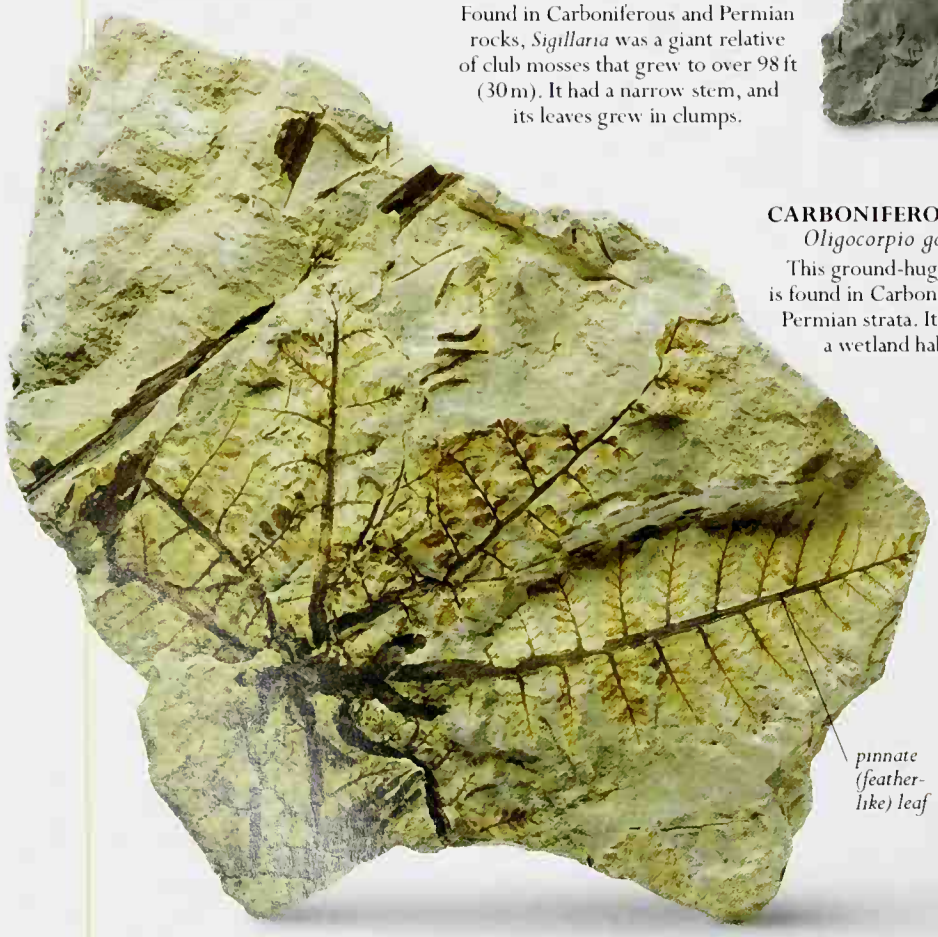
SEED FERN SEEDS
Trigonocarpus odomsi
The name *Trigonocarpus* is given to fossil seeds from seed ferns found in Carboniferous strata. Each seed has three ribs.

HORSETAIL FOLIAGE
Asterophyllites equisetiformis
Found in Carboniferous and Permian strata, *Asterophyllites* had needle-shaped leaves and a structure similar to that of modern horsetails.

CLIMBING HORSETAIL
Sphenophyllum emarginotum
Found fossilized in rocks of Devonian to Triassic age, this horsetail had wedge-shaped leaves and long, soft stems adapted for climbing.

SIGILLARIA STEM
Sigillaria aeveoloris
Found in Carboniferous and Permian rocks, *Sigillaria* was a giant relative of club mosses that grew to over 98 ft (30 m). It had a narrow stem, and its leaves grew in clumps.

LEPIDODENDRON ROOT
Stigmorio ficoides
Occurring in Carboniferous to Permian rocks, *Stigmaria* is the name for the fossil roots of the club moss relative, *Lepidodendron*.



CARBONIFEROUS FERN
Oligocorpio gothonii
This ground-hugging fern is found in Carboniferous and Permian strata. It occupied a wetland habitat.

SALVINIA RHIZOME
Solvinio formosa
A floating water fern from the tropics, *Salvinia* is found fossilized in rocks from Cretaceous to Recent strata.

CRETACEOUS FERN
Weichselio reticuloto
Found fossilized in Cretaceous strata, *Weichselia* was similar to modern bracken and had fronds that were divided twice.

SEED FERN LEAFLETS
Dicrodium sp.
A seed fern from the Triassic Period, *Dicrodium* had pinnate leaves and its fronds were about 3 in (7.5 cm) long.

PALEOZOIC CONIFER
Lebachia piniformis
A cone-bearing plant from Carboniferous and Permian strata, *Lebachia* is an ancestor of modern conifers.

CONIFER SEED CONES
Taxodium dubium
Found in Jurassic strata, *Taxodium* is related to modern cypress trees. It grew in damp habitats and had needlelike leaves.

COAST REDWOOD CONE
Sequoia dakotensis
Cones of the giant evergreen tree *Sequoia* have been found in Cretaceous and Recent rocks. Some living members of *Sequoia* are over 2,000 years old.

CRETACEOUS CONIFER
Glyptostrobus sp.
This conifer grew in swamps during the Cretaceous Period and into the Cenozoic Era. *Glyptostrobus* was an important coal-forming tree.

SUBFOSSIL TREE RESIN
Kauri pine amber
Amber is the hardened resin from pine trees, such as Kauri pines. First occurring in the Early Cretaceous, it often contains fossils of insects that perished on the fragrant, sticky resin.

JURASSIC CONIFER
Araucaria mirabilis
This extinct monkey-puzzle tree, *Araucaria*, bore characteristic female cones with spiraly arranged scales attached to a central axis.

CARBONIFEROUS GYMNOSPERM
Cordaites sp.
An ancestor of the conifers, *Cordaites* grew during the Carboniferous and Permian Periods. It was a tree-sized plant that reproduced by seed.

GIGANTOPTERID LEAVES
Gigantopteris nicotianaefolia
A flowerless plant from Permian times, this species was so named because its leaves resembled those of tobacco plants.

TRIASSIC GINKGO
Baiera munsteriana
Growing up to 6 in (15 cm) in length, the fan-shaped leaves of *Baiera* were split into separate ribs. In living ginkgos, the leaves are almost entire.

PERMIAN GINKGO LEAVES
Psygmophyllum multipartitum
Still found in China, ginkgos first appeared in the Permian Period. The fan-shaped leaves can be identified in fossils of *Psygmophyllum*, a precursor of the modern-day ginkgo.

OAK TREE TRUNK
Quercus sp.
The well-known oak, *Quercus*, first occurs as fossils in Cretaceous strata. There are over 500 species of oak living today.

PALM FRUIT
Nipa burtinii
Fossils of *Nipa* date from the Eocene Period onward. This palm holds its woody seeds in a 10 in (25 cm) ball-shaped fruit.

MAGNOLIA LEAF
Magnolia longipetiolata
One of the earliest genera of flowering plants, magnolias first appeared in the Cretaceous Period. Early insects fed on their nectar.

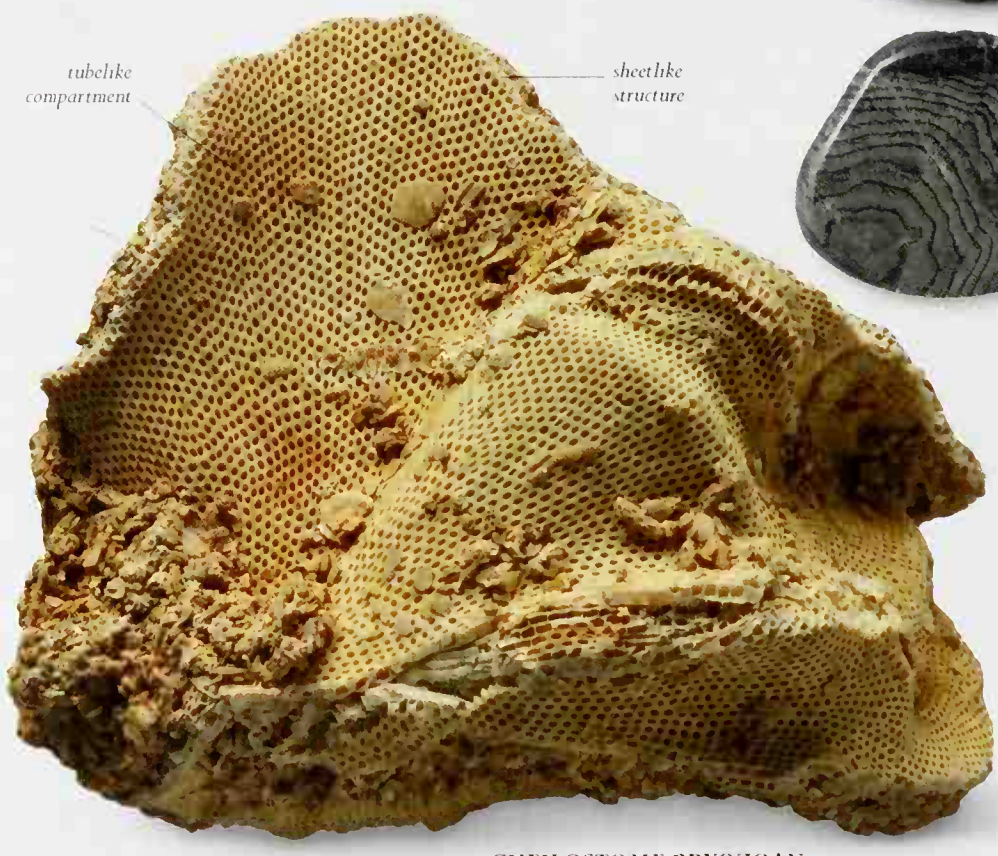
FOSSIL INVERTEBRATES

Invertebrates, animals without solid internal skeletons, are among the most common fossils found. They first appeared in the Precambrian, but it is only in Early Cambrian times that complex invertebrates such as trilobites become numerous in the fossil record. Fossils of invertebrates such as arthropods, mollusks, brachiopods, echinoderms, and corals are especially common, because they had hard external structures and lived in the sea, where most fossil-bearing rocks form.

ARCHAEOCYATHID
Metaldetes taylori
These reef-building organisms are known only from the Cambrian Period. *Metaldetes* had a cuplike structure, not unlike that of a coral.

CALCAREOUS SPONGE
Peronidella pistilliformis
Characterized by needlelike spicules (in the form of calcite) fused together, *Peronidella* is found in Triassic and Cretaceous rocks.

STROMATOPOROID
Stromatopora concentrica
Found in rocks ranging from the Ordovician to the Permian, often in reef limestone, the fossil sponges in this group were made of porous, calcium-rich tubes.



CHEILOSTOME BRYOZOAN
Biflustra sp.
Found in Cenozoic rocks, this bryozoan genus is extant. It has minute compartments, which house zooids—the soft-bodied individuals of a colony.

TREPOSTOME BRYOZOAN
Diplotrypa sp.
A bryozoan from Ordovician strata, *Diplotrypa* was a small invertebrate, not unlike coral, that lived in dome-shaped colonies.

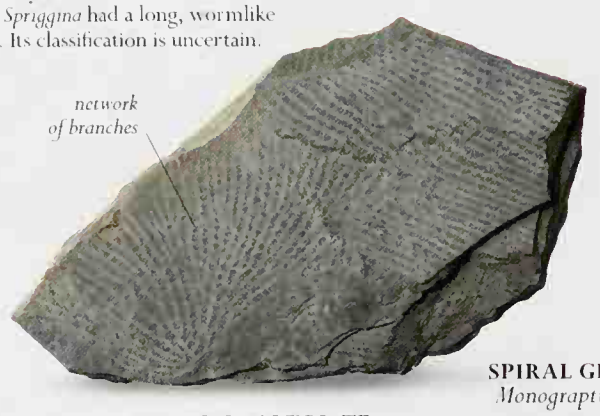
LACE CORAL
Schizoretepora notopachys
A lace coral, *Schizoretepora* is found in Eocene to Pleistocene strata. It lived on rocky seabeds.

BRANCHING BRYOZOAN
Constellaria sp.
A bryozoan that built branching colonies on the seabed, *Constellaria* occurs in Ordovician strata.

SERPULID WORM
Rotularia bognoriensis
Found in Jurassic to Eocene rocks, *Rotularia* is a genus of serpulid worm. Like all serpulids, each worm protected its soft body by producing coiled tubes made of calcium carbonate.

SPRIGGINA
Spriggina flounderi
A very early fossil found in Precambrian rocks, *Spriggina* had a long, wormlike body. Its classification is uncertain.

"TUNING FORK" GRAPTOLITE
Didymograptus murchisoni
A graptolite (extinct colonial invertebrate) with two stipes (branches), *Didymograptus* is found in Ordovician rocks. It grew from ¾ to 23½ in (2–60 cm) in length.



BRANCHING GRAPTOLITE
Rhabdinopora socialis
Until recently, this graptolite was called *Dictyonema*. It had numerous thin, radiating stipes, and is from Ordovician strata.

SPIRAL GRAPTOLITE
Monograptus convolutus
A single branch, with thecae (cuplike structures) on one side, characterizes *Monograptus*, which is found in Early Silurian strata. *M. convolutus* had unusual coiling.

TABULATE CORAL
Catenipora sp.
A simple, tabulate coral with a chainlike structure, *Catenipora* lived in warm, shallow seas during Ordovician and Silurian times.

SCLERACTINIAN CORAL
Meandrina sp.
Shaped like the human brain, this colonial coral has ridges and valleys on its surface. First found in Eocene rocks, *Meandrina* still survives today.

RUGOSE CORAL
Gonophyllum pyramidale
A solitary coral occurring in Silurian rocks, *Gonophyllum* has a cone-shaped structure in which the polyp lived.

CAMBRIAN TRILOBITE
Paradoxides bohemicus
Some *Paradoxides* trilobites grew to nearly 3¼ ft (1 m) in length. This species had long spines on its body and is from Cambrian strata.

SILURIAN TRILOBITE
Dalmanites caudatus
Common in the Silurian Period, *Dalmanites* had a segmented thorax and a pointed tail spine.

DEVONIAN ENROLLED TRILOBITE
Phacops sp.
Characterized by compound eyes, *Phacops* is found in Devonian strata. Trilobites could roll up, like many modern arthropods.

ORDOVICIAN TRILOBITE
Eodalmanitina macrophtalma
An Ordovician trilobite, *Eodalmanitina* had large, crescent-shaped eyes. Its thorax was composed of 11 segments.

HORSESHOE CRAB RELATIVE
Euproops rotundatus
Related to horseshoe crabs, *Euproops* had a crescent-shaped headshield and long tail spine.

LOBSTER
Eryma leptodactylina
A fossil lobster from rocks of Jurassic and Cretaceous times, *Eryma* was 2¾ in (6 cm) long, and similar to modern species.

CRAB
Avitelmessus grapsoideus
Covered with many spines, this crab is from the Cretaceous Period. It grew to 10 in (25 cm) in width.

COCKROACH RELATIVE
Archimylacris eggintoni
A relative of cockroaches from the Carboniferous Period, *Archimylacris* had hind wings with a distinctive vein pattern.

»

» FOSSIL INVERTEBRATES

ARTICULATE BRACHIOPOD
Leptaena rhomboidalis
A brachiopod from Ordovician, Silurian, and Devonian strata, *Leptaena* grew to about 2 in (5 cm) in width. Its shell had concentric and radial ribs.

RHYNCHONELLID BRACHIOPOD
Homeorhynchia acuta
Found in Early Jurassic strata, *Homeorhynchia* was a small brachiopod that grew to about ⅜ in (1 cm) in width.

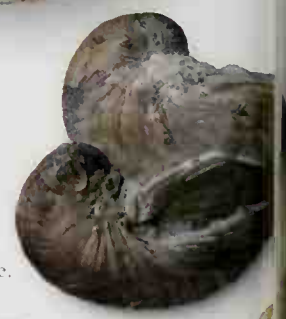
SPIRIFERID BRACHIOPOD
Spiriferina walcotti
A common brachiopod from Triassic and Jurassic strata, *Spiriferina* had a rounded shell up to 1¼ in (3 cm) wide, with clearly visible growth lines.

SCALLOP
Pecten maximus
Found in Jurassic to Recent strata, this scallop was a bivalve mollusk that swam by flapping its valves, which were ribbed.

SWAMP CLAM
Carbonicola pseudorobusta
Occurring in nonmarine rocks of the Carboniferous Period, *Carbonicola* had a tapered shell. Its fossils have been used in the relative dating of these rocks.

CLAM
Crassatella lamellosa
A small bivalve from Cretaceous to Miocene times, *Crassatella* had marked concentric growth lines on its shell.

MUSSEL RELATIVE
Ambonychia sp.
Found in Ordovician strata, *Ambonychia*, an early bivalve mollusk, grew up to 2½ in (6 cm) wide. Both valves had radial ribs on the surface.



OYSTER
Gryphaea arcuata
This fossil oyster occurs in Triassic and Jurassic rocks. *Gryphaea* had one large, hooked valve and a smaller, flat one.

ORDOVICIAN GASTROPOD
Murchisonia bilineata
A gastropod mollusk from Silurian to Permian strata, *Murchisonia* grew up to 2 in (5 cm) tall, with ridges around its whorls.

JURASSIC GASTROPOD
Pleurotomaria anglica
Found in Jurassic and Cretaceous rocks, this gastropod mollusk had a broad shell with a combination of radial and spiral patterns.

ROSTROCONCH
Conocardium sp.
Occurring in Devonian and Carboniferous strata, *Conocardium* resembled clams, but its shell had no functional hinge.

NAUTILOID
Vestinautilus cariniferous
This early *Nautilus* relative had very open coiling and little shell ornamentation. *Vestinautilus* is found in Carboniferous rocks.

DEVONIAN AMMONOID
Solclymenia paradoxa
An Early Devonian ammonoid, *Solclymenia* had thin ribs across the shell. Some species had unusual, triangular shells.

CARBONIFEROUS AMMONOID
Goniatites crenistria
An ammonoid mollusk from Devonian and Carboniferous rocks, *Goniotites* had angular sutures where the chamber walls joined the shell.

TRIASSIC AMMONOID
Ceratites nodosus
Found in Triassic strata, *Ceratites* was an ammonoid mollusk. Its heavily ornamented shell had open coiling and strong ribs.

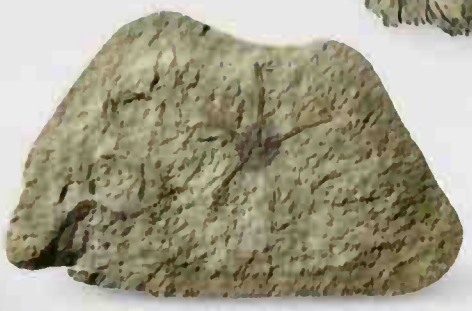
AMMONITE
Mortoniceras rostratum
This ammonite mollusk from the Cretaceous Period grew up to 4 in (10 cm) in diameter, with ribs across the shell.

BELEMNITE
Pachyteuthis abbreviata
A squid relative from the Jurassic, *Pachyteuthis* had a calcite guard. It was about 4 in (10 cm) long.

CYSTOID
Pseudocrinites bifasciatus
Characterized by rhomboid-shaped respiratory structures, *Pseudocrinites* lived in Silurian and Devonian times. It was attached to the seabed by its stem.

DEVONIAN CRINOID
Cupressocrinites crassus
Up to 1¼ in (3 cm) in diameter, this crinoid from Devonian strata had a tall, five-sided cup at the end of its stem.

JURASSIC CRINOID
Pentacrinites sp.
Named for its star-shaped ossicles (stem segments), *Pentacrinites* grew to over 3¼ ft (1 m) in height. It is often found attached to fossil wood.



BRITTLESTAR
Lapworthura miltoni
An early fossil brittlestar, *Lapworthura* is from Ordovician and Silurian strata. It grew to 4 in (10 cm) in diameter. This species had five relatively short, thick arms.

STARFISH
Tropidaster pectinatus
This extinct starfish from the Early Jurassic was about 1 in (2.5 cm) wide. It had five thick arms.

BLASTOID
Pentremites pyriformis
This echinoderm from the blastoid group lived during Carboniferous times. It had long, armlike structures that were used for feeding.

SEA URCHIN
Hemicidaris intermedia
This common sea urchin from Jurassic strata grew to around 1½ in (4 cm) in diameter. Its many bumps (tubercles) supported stout spines.

HEART URCHIN
Lovenia sp.
A heart-shaped, burrowing sea urchin, *Lovenia* is known from the Palaeocene and still exists today. It is up to 2 in (5 cm) in diameter.

FOSSIL VERTEBRATES

Fossilized vertebrate remains are not as common as those of invertebrates, since many vertebrates lived on land, where fewer fossils form, and they evolved much later than the invertebrates. Fish were the earliest vertebrates to evolve, some dating back to Cambrian times. Their rapid evolution in the Silurian and Devonian led to amphibians, which first appeared in the Devonian Period. Dinosaurs flourished during the Mesozoic Era, toward the end of which mammals began to diversify.

ZENASPID FISH
Zenaspis sp.
Found in Devonian strata, *Zenaspis* had a massive headshield. Up to 10 in (25 cm) long, its body was covered in bony scales.

PLACODERM
Bothriolepis canadensis
A Devonian placoderm (an extinct group of jawless fish), *Bothriolepis* had large head and trunk-shields and spinelike pectoral fins.

EARLY FISHLIKE VERTEBRATE
Loganellia sp.
A primitive, jawless, flattened "fish," *Loganellia* was covered with toothlike scales. Up to 4¾ in (12 cm) long, it is found in Devonian rocks.

PSAMMOSTEID FISH
Drepanaspis sp.
A jawless, primitive fish, *Drepanaspis* had a flattened headshield. It is found only in Devonian strata.

LOBE-FINNED FISH
Eusthenopteron foordi
The bones in the heavily built fins of this Late Devonian fish were similar to those in the limbs of land-dwelling vertebrates (tetrapods).

SHARK TOOTH
Carcharocles auriculatus
The serrated edges of the teeth of this Cenozoic shark could easily cut through flesh.

SHOAL OF DACE
Leuciscus pachecoi
Found in Miocene strata, extinct species of *Leuciscus* or dace resembled modern bony fish. *L. pachecoi* grew to 2½ in (6 cm) in length.

STINGRAY
Heliobatis radians
Found in Eocene strata, *Heliobatis* was a primitive stingray that grew to about 12 in (30 cm) in length and had a skeleton of cartilage.

PRIMITIVE FROG
Rana pueyoi
Dating back to Miocene times, *Rana* is a genus of frogs. *R. pueyoi* grew to 6 in (15 cm) in length and shared features such as long hind limbs with modern frogs.

DIPLOCAULID AMPHIBIAN
Diplocaulus magnicornis
A salamander-like amphibian from the Permian Period, *Diplocaulus* had protrusions on the sides of its skull. It grew up to 3¼ ft (1 m) in length.

SKULL OF LARGE, PREDATORY BONY FISH
Xiphactinus sp.
A bony fish from Late Cretaceous strata, *Xiphactinus* was a marine predator with a muscular body and large front teeth.

GIANT MONITOR LIZARD VERTEBRA
Varanus priscus
A huge monitor lizard, *Varanus priscus* grew to 23 ft (7 m) in length. It is found in rocks of Pleistocene age.

DIMETRODON SKULL
Dimetrodon loomisi
Noted for a sail-like structure on its back, *Dimetrodon* was an early relative of mammals from the Permian Period. A high skull and short snout translated into a powerful bite.

CYNODONT SKULL
Cynognathus crateronotus
A carnivore with a stout skull and large canine teeth, *Cynognathus* belonged to a group of mammal precursors called cynodonts. It is found in Triassic strata.

DICYNODONT SKULL
Pelanomodon sp.
This tuskless herbivore was a dicynodont—a member of a group of mammal relatives that lived in the Permian and Triassic Periods.

PLESIOSAUR FLIPPER
Cryptoclidus eurymerus
Growing up to 26 ft (8 m) in length, *Cryptoclidus* was a long-necked plesiosaur from the Jurassic Period.

MARINE TURTLE SKULL
Puppigerus crassicostata
Fossilized marine turtles are found in rocks ranging from the Mesozoic Era to Recent times. *Puppigerus* had a heavy shell and is found in Eocene strata.

EARLIEST BIRD
Archaeopteryx lithographica
Archaeopteryx was the earliest-known bird. Very few fossils have been found, from Jurassic strata in Germany.

GIANT GROUNDBIRD SKULL
Phorusrhacus inflatus
A carnivore up to 8¼ ft (2.5 m) tall, *Phorusrhacus* was a flightless bird with a powerful beak. It is found in Miocene rocks.

EARLY HORSE TEETH
Protorohippus sp.
A dog-sized, many-toed ancestor of the modern horse, *Protorohippus* is found in Eocene strata. It had low-crowned molars.

SABER-TOOTHED CAT SKULL
Smilodon sp.
Large, curved canine teeth were typical of *Smilodon*, which was the size of a tiger and lived in the Pleistocene Period.

EARLY ELEPHANT JAW
Phiomia serridens
Found in Eocene to Oligocene strata, *Phiomia* was 8¼ ft (2.5 m) tall. It had tusks in its upper jaw, and a small trunk.

ANTHROPOID SKULL
Proconsul africanus
The first fossil anthropoid (apelike primate) to be found in Africa, *Proconsul* comes from Miocene strata.

NOTOUNGULATE
Toxodon platensis
Growing to about 8¾ ft (2.7 m), *Toxodon* had a sturdy body with a hippopotamus-like head. It lived from Pliocene to Pleistocene times.

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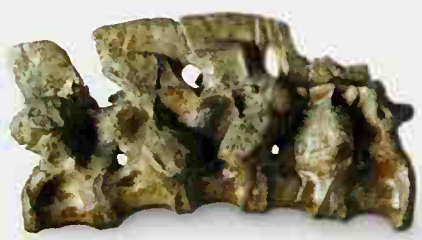
DIPLODOCUS TAIL VERTEBRA
Diplodocus longus
Found in Jurassic strata, *Diplodocus* was a giant plant eater that grew up to 89 ft (27 m) in length. Its tail was long and whiplike.

BRACHIOSAURUS THIGH BONE
Brachiosaurus sp.
A huge, plant-eating dinosaur that grew to 82 ft (25 m) in length, *Brachiosaurus* lived in the Jurassic and Cretaceous Periods.

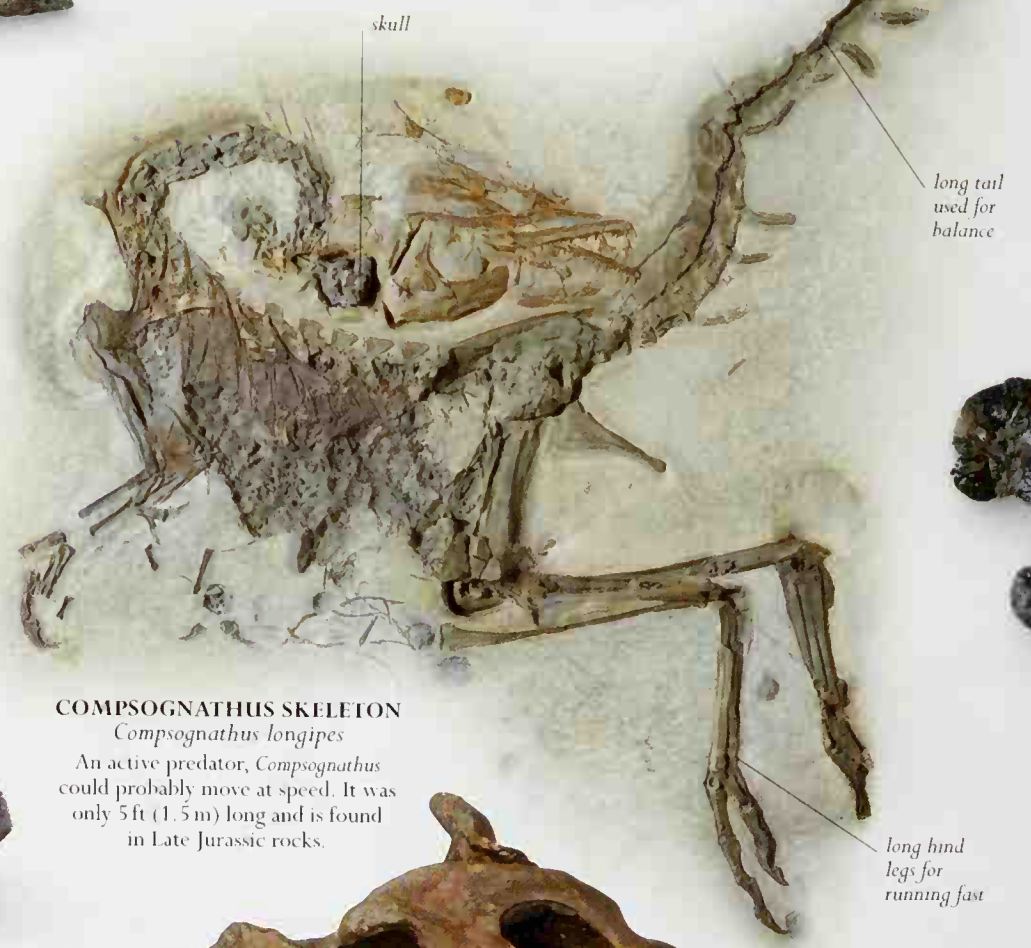
PLATEOSAURUS SKULL
Plateosaurus sp.
A bulky plant eater from the Late Triassic, *Plateasaurus* grew to about 26 ft (8 m) in length and had a very small head.

COELOPHYSIS SKELETON
Coelophysis bauri
Fossils of *Coelophysis* are found in Triassic rocks. Only 9¾ ft (3 m) long, this carnivore had a birdlike skeleton.

PROCERATOSAURUS PARTIAL SKULL
Proceratosaurus bradleyi
A carnivore from Middle Jurassic strata in Gloucestershire, England, *Proceratosaurus* had a bony crest on its head.



MEGALOSAURUS SACRAL VERTEBRAE
Megalosaurus bucklandi
Found in Middle Jurassic strata, *Megalosaurus* was 30 ft (9 m) long, with a large head and strong hind limbs. It was carnivorous.



COMPSOGNATHUS SKELETON
Compsognathus longipes
An active predator, *Compsognathus* could probably move at speed. It was only 5 ft (1.5 m) long and is found in Late Jurassic rocks.

GALLIMIMUS SKULL
Gallimimus bullatus
Growing up to 20 ft (6 m) long, *Gallimimus* had a birdlike, beaked skull, and long neck and legs.

ALBERTOSAURUS SKULL
Albertosaurus sp.
A predator and close relative of *Tyrannosaurus rex*, *Albertasaurus* grew to 26 ft (8 m) in length and is found in Late Cretaceous rocks.

DASPLETOSAURUS JAW
Daspletosaurus torosus
This Cretaceous dinosaur had massive hind legs and small arms, and it grew to a length of 30 ft (9 m). It had a powerful jaw with the formidable teeth of a carnivore.

SCELIDOSAURUS FOOT
Scelidosaurus harrisonii
Found in Early Jurassic rocks, *Scelidosaurus* grew to 13 ft (4 m) in length and was covered with sharp, bony knobs. It had long toes and blunt claws.

STEGOSAURUS PLATE
Stegosaurus sp.
A Late Jurassic plant eater, *Stegosaurus* grew up to 30 ft (9 m) in length. It had two rows of huge bony plates running along its back.

ANKYLOSAURUS SKULL
Ankylosaurus magniventris
Found in Cretaceous rocks, *Ankylosaurus* was a heavily armored plant eater. It grew to about 20 ft (6 m) in length.

EUOPLOCEPHALUS TAIL CLUB
Euoplocephalus tutus
Growing to 23 ft (7 m) in length, *Euoplocephalus* lived in the Late Cretaceous. A bony club at the tip of its tail was probably used for defense.

STYRACOSAURUS SKULL
Styracosaurus albertensis
Although similar to *Triceratops*, *Styracosaurus* had slender horns along the back of its skull. It is found in Late Cretaceous rocks.

PARASAUROLOPHUS SKULL
Parasaurolophus walkeri
A Cretaceous herbivore, *Parasaurolophus* had a long, curved, hollow crest on its skull. This may have been used to make deep, resonating calls.

HYPSILOPHODON TOE
Hypsilophodon foxii
Dating back to the Cretaceous Period, *Hypsilophodon* was a swift-moving herbivore. It grew up to 7½ ft (2.3 m) in length.

STEGOCERAS SKULL
Stegoceras validum
Found in Cretaceous strata, *Stegoceras* grew to 6½ ft (2 m) in length. Its small, serrated teeth indicate it was probably a herbivore.

PACHYCEPHALOSAURUS SKULL
Pachycephalosaurus wyomingensis
Living at the end of the Cretaceous Period, *Pachycephalosaurus* had a thick, domed skull and grew up to 16 ft (5 m) in length.

PSITTACOSAURUS SKELETON
Psittacosaurus sp.
One of the earliest horned dinosaurs, *Psittacosaurus* is found in Cretaceous strata. It was a plant eater and grew to 6½ ft (2 m) in length.

TRICERATOPS SKULL
Triceratops prorsus
A massive horned and plated skull characterized *Triceratops*, a plant eater from Late Cretaceous strata.

EUOPLOCEPHALUS

Euoplocephalus belonged to a family of dinosaurs called the ankylosaurids, which were characterized by an armored head and bony plating on the body. This dinosaur grew to about 23 ft (7 m) in length and weighed around two tons. Its tail, body, and neck were covered by plates and bands of tough, leathery skin set with bony studs. Two rows of larger spikes ran along its back. Even its eyes were protected by bony eyelids. Fused bony knobs on the end of the long tail formed a tail club, which the dinosaur could swing at attacking predators. *Euoplocephalus* was a herbivore—its beaked mouth was ideally suited for grazing on vegetation in the thick forests of the Late Cretaceous. It may even have used the blunt hooves at the end of each toe to dig in the ground for roots and tubers. *Euoplocephalus* was probably a solitary dinosaur, though juveniles may have lived in herds.

SIZE 23 ft (7 m)
DATE Late Cretaceous
DISTRIBUTION North America
GROUP Ankylosaurids

> ARMORED HEAD
The head had a massive skull, with protective spikes at the back and a beaked mouth. The name *Euoplocephalus* means "well-armored head."

v NECK VERTEBRAE
Although the head was relatively small and the neck short, the neck vertebrae had to be strong to support the head's weighty, studded armor plating.

< STUDDED PLATES
One of the most important features of *Euoplocephalus* was its armor plating. This was made of tough plates of skin studded with ridged ovals of bone.

^ FRONT FOOT
This dinosaur's limbs were short, stocky, and strong. The front feet had short, sturdy toes, which helped support the considerable body weight.

^ TAIL CLUB
The massive tail club was made of fused bones—two large and several smaller bones. This weapon was probably used in defense.

^ TAIL VERTEBRAE
About halfway along the tail, the typical tail vertebrae—armed with spikes—gave way to a fused, bony structure. This rigid structure would have supported the club at the end of the tail. The tail would have been quite muscular.

WALKING TANK >
Euoplocephalus had a wide, low-slung body, supported by short, stout limbs. In cross section it would have been almost round. Its small head was protected at the back by spikes, and its beaked mouth would have had small, ribbed teeth adapted for munching plants.

short shoulder blade

broad, rounded ribcage

in life, bony studs were covered with scaly horn

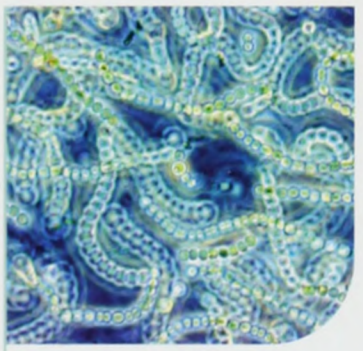
elbow joint

bony studs and spines along back
head spike
large nasal cavity suggests this dinosaur had a keen sense of smell
hind feet had three toes, each tipped with a blunt hoof
massive leg bones supported the weight of the armored body

MICROS
LIFE

COPIC

Despite their tiny size, microscopic organisms dominate life on Earth. They were the first living things to evolve, and they underpin all the world's ecosystems, releasing and recycling nutrients that other forms of life need to survive. From the simplest prokaryotes to the most complex protists, they make up a constellation of varied and versatile life forms that largely goes unseen.



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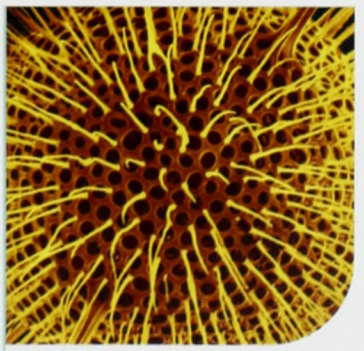
PROKARYOTES

Life at its most basic, prokaryotes have tiny cells without nuclei. Most live as individuals, though some form colonies such as filaments and chains. Prokaryotes include bacteria and archaea.



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PROTISTS

Among the most numerous living things, protists are also some of the most diverse. Some have no fixed shape, but many have elaborate mineral skeletons or shells. They are typically single-celled.

PROKARYOTES

An alien visiting Earth might conclude that its true masters were the prokaryotes—the archaea and the bacteria. They outnumber, and are more diverse than, the more complex life forms known as the eukaryotes, and thrive in every nook and cranny of the planet.

DOMAIN	ARCHAEA
KINGDOMS	5
CLASSES	9
ORDERS	18
FAMILIES	28
SPECIES	More than 2,000 known

DOMAIN	BACTERIA
KINGDOMS	28
CLASSES	49
ORDERS	About 79
FAMILIES	About 232
SPECIES	More than 8,000 known

Hydrothermal vents at the bottom of oceans are home to various thermophile archaea living at high temperatures.

***Staphylococcus* bacteria** are common agents of food poisoning in humans, forming microscopic clusters in food.

DEBATE

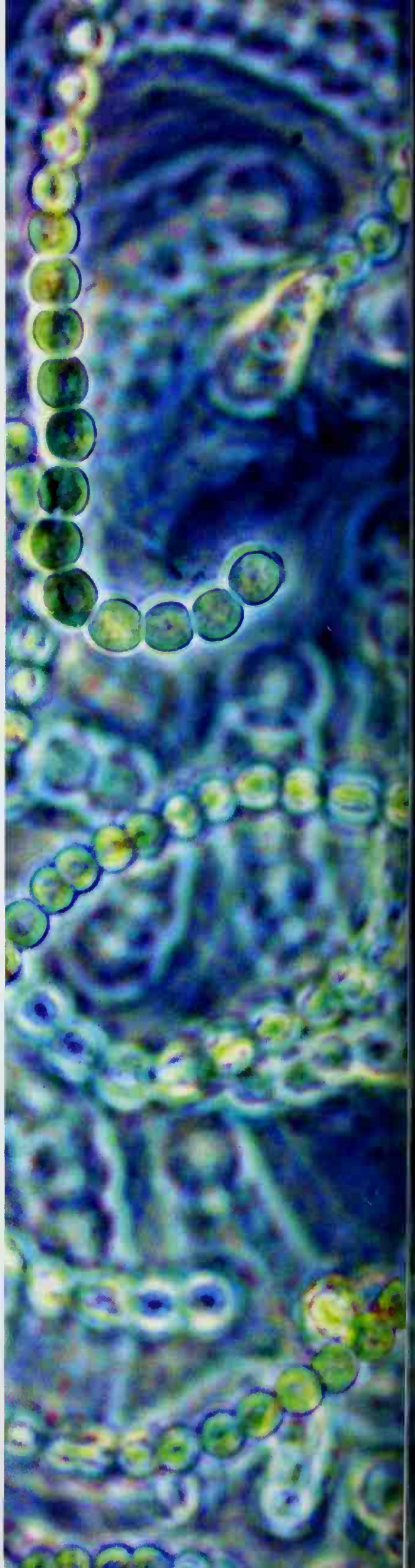
CAULDRON OF LIFE

Many archaea are adapted for extremes; in hot water their fragile DNA is lagged by protective protein. Similiar protein braces the longer chromosomes of eukaryotes (fungi, plants, and animals). So perhaps what began as insulation in primeval pools evolved into a "scaffold" for the extra DNA needed for more complex life.

Prokaryotes are single-celled organisms and among the earliest forms of life. They also form one of life's two fundamental divisions, along with eukaryotes. While all living cells possess DNA, eukaryote cells also have a nucleus, and most also have mitochondria, which are energy-generating structures. Prokaryote cells have neither nucleus nor mitochondria. The archaea and bacteria are only distantly related to each other, having evolved from separate, as yet unknown genetic origins. Archaea cells are contained by chemically unique membranes overlain by a tough outer cell wall, and within the cell their DNA is often protein-covered. Bacteria cells have very different physical and chemical makeups, particularly in their cell wall. These properties make the typical archaea especially suited to harsh habitats, while bacteria are ubiquitous and thrive in every environment.

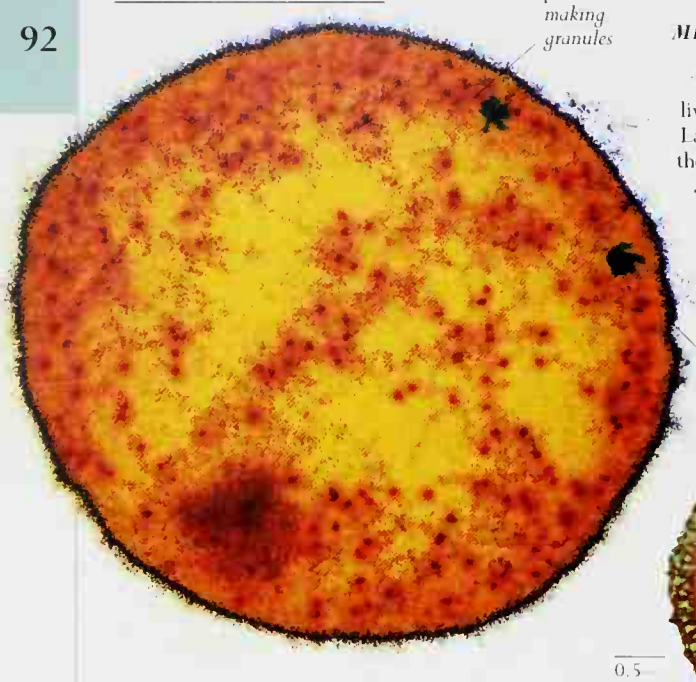
SMALLEST LIVING THINGS

All prokaryotes are tiny, their size measured in microns or micrometers (µm); 1 µm equals one-thousandth of a millimeter. A human hair is about 80 µm thick, but most prokaryotes are just 1–10 µm in length, and only photographed through an electron microscope. Yet they survive in almost every corner of the biosphere, from the outer atmosphere to deep within Earth's crust, and from ocean depths to inside the human body. For instance, the bacteria in your gut outnumber your own cells by about ten to one. Some prokaryotes thrive in boiling water or freezing ice, survive radiation, and even live off poisonous gases and corrosive acids. Most get nourishment from dead material, others from infesting living bodies. While some make food in darkness, by using the energy in minerals, others use photosynthesis, using the energy in light to convert carbon dioxide and water into food and oxygen. Although notorious for causing infectious diseases, prokaryotes are actually essential to human health, with humans depending on their gut bacteria to help break down food and even to manufacture essential nutrients. For almost four billion years, prokaryotes have profoundly influenced Earth's climate, rock formation, and evolution of other life.



MICROSCOPIC CYANOBACTERIA COLONY >
Although bacteria have single cells, the cells of some, such as cyanobacteria, can join together in spectacular, long filaments.

ARCHAEA



METHANOCOCCOIDES BURTONII

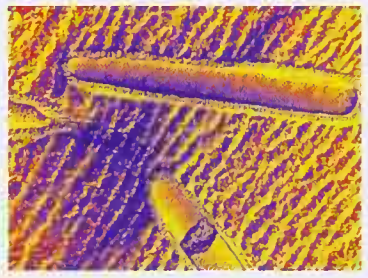
This methane producer lives at the bottom of Ace Lake in Antarctica, where there is no oxygen and the average temperature is 33°F (0.6°C).

STAPHYLOTHERMUS MARINUS

Discovered in a hydrothermal vent on the sea floor, this species grows best at 184–198°F (85–92°C). It forms grapelike clusters, and can grow comparatively large.

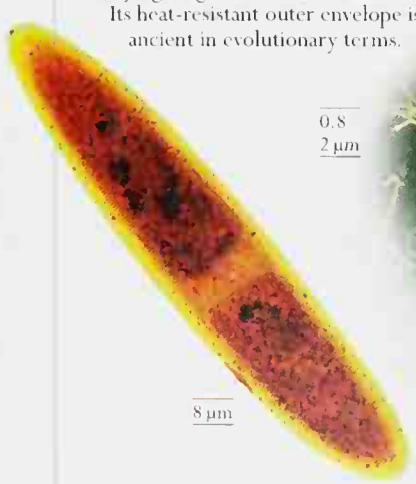
SULFOLOBUS ACIDOCALDARIUS

Like many archaea, this thermophile has a heat-resistant cell wall. It thrives in the high temperatures of hot springs in Yellowstone National Park, USA.



THERMOPROTEUS TENAX

This species forms rod-shaped cells of varying length but constant diameter. Its heat-resistant outer envelope is ancient in evolutionary terms.



METHANOSPIRILLUM HUNGATEI

Discovered in human sewage, this archaean generates large amounts of methane during sewage disposal. Each cell is confined within a hollow sheath.

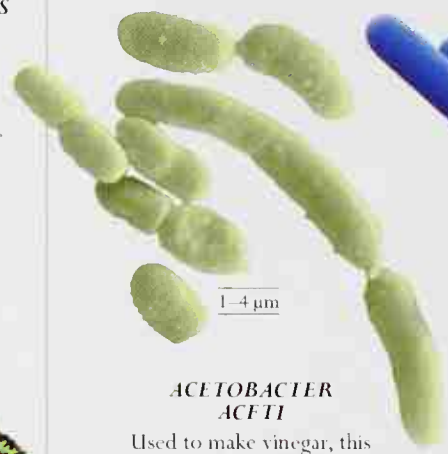
DESULFUROCOCCUS MOBILIS

This anaerobe thrives where oxygen is limited or absent and uses sulphur-containing compounds in place of oxygen. An extreme thermophile, it grows best at 184°F (85°C).

PYROCOCCUS FURIOSUS

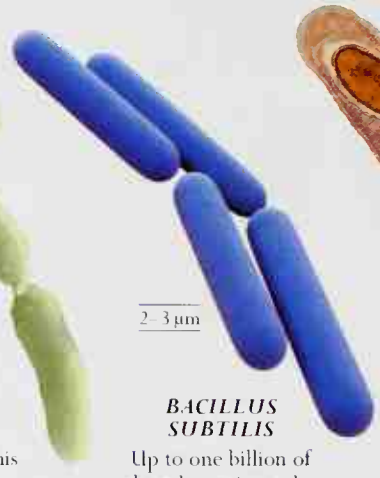
Pyrococcus means "fireberry," reflecting this archaean's shape and its tolerance of extreme temperatures: it grows best at 212°F (100°C).

BACTERIA



ACETOBACTER ACETI

Used to make vinegar, this species is also a common contaminant wherever alcohol is brewed, causing discolouration and souring of beer in particular.



BACILLUS SUBTILIS

Up to one billion of these bacteria can be found in a single gram of soil. It is usually found in an inactive spore form.

BACILLUS THURINGIENSIS

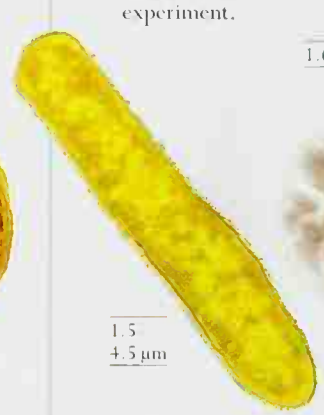
This bacterium produces toxic crystals insoluble in the human gut but lethal to insects, and is therefore commercially marketed as an insecticide.

DEINOCOCCUS RADIODURANS

This species is known as the world's toughest bacterium. It was discovered in meat that had been exposed to doses of radiation in an experiment.

BORDETELLA PERTUSSIS

This species causes pertussis, or whooping cough, a respiratory infection marked by severe, spasmodic coughing episodes, and breakdown of blood cells.

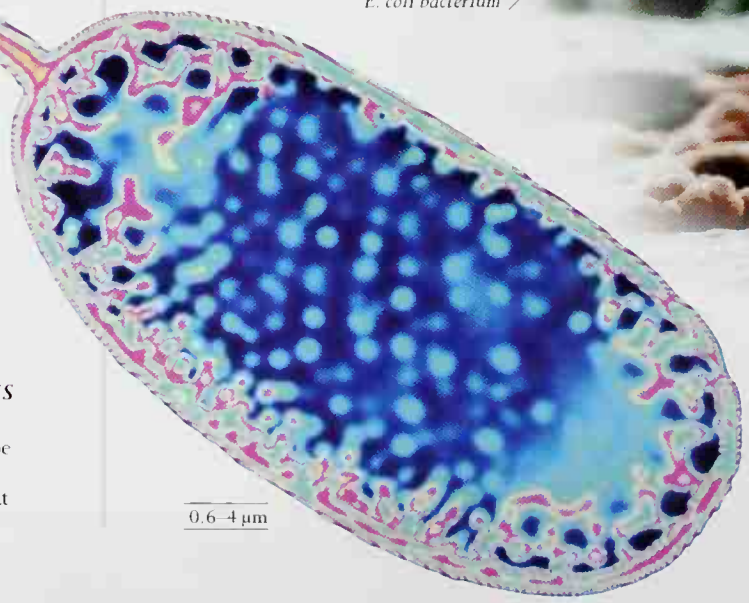


BACTEROIDES FRAGILIS

Forming a large part of the human gut's flora, this bacterium is usually harmless to its host. But it can also cause disease, invading tissues to form pus-filled abscesses.

ESCHERICHIA COLI

An organism much studied by scientists, the rod-shaped *E. coli* lives harmlessly in the gut, although virulent strains are a major cause of food poisoning.



NITROBACTER SP.

This genus of soil bacteria plays a role in the nitrogen cycle by oxidizing nitrites into nitrates. This helps purify water and fertilize the soil.

3–8 µm

4–8 µm

2–3 µm

1–3 µm

cells dividing

DNA

3–7 µm

pigmented membranes for photosynthesis

NOSTOC SP.

This cyanobacteria forms gelatinous filaments in colonies that are hardy enough to survive from the poles to the tropics.

CLOSTRIDIUM BOTULINUM

This bacterium thrives where oxygen is limited or absent. Living in soil, it produces the neurotoxins that cause botulism, but which also have medical and cosmetic uses.

CLOSTRIDIUM TETANI

A soil organism that can grow in dead tissue in wounds or burns, *C. tetani* produces tetanospasmin, the neurotoxin that causes tetanus.

SALMONELLA ENTERICA

Belonging to the same family as *E. coli*, some subspecies of *Salmonella* bacteria cause gastroenteritis, others cause typhoid fever.

SHIGELLA DYSENTERIAE

This gut bacteria produces shiga toxin, which can cause epidemic dysentery. As few as 10 bacteria are needed to cause an infection.

STREPTOCOCCUS PNEUMONIAE

This bacterium, present inside humans, can cause pneumonia. In children and the elderly it is the leading cause of invasive infection that moves into all parts of the body.

0.9 µm

1.5–6 µm

1 µm

LACTOBACILLUS ACIDOPHILUS

Found in the intestine and vagina, this bacterium has nutritional and antimicrobial properties. It is used in probiotic drinks and supplements.

STAPHYLOCOCCUS EPIDERMIDIS

This spherical bacterium can be found on the skin as part of normal flora, but can cause infections in immune-compromised patients.

flagellum helps propel organism

1–3 µm

0.4–0.5 µm

1.5–2 µm

VIBRIO CHOLERAE

Highly mobile curved rods with a single flagellum at one end, this species secretes a potent enterotoxin that causes cholera.

FUSOBACTERIUM NUCLEATUM

This species makes its home in the human mouth, and forms a major component of plaque. It can also cause premature birth.

PSYCHROBACTER URATIVORANS

This species is a psychrophile, or cryophile, which means it thrives at very low temperatures, thanks to natural antifreeze molecules in its cytoplasm within the cell membrane.

numerous rods of bacteria grouped together

NITROSOSPIRA SP.

Filling a vital ecological niche, this nitrifying soil bacteria oxidizes ammonia to form nitrites as part of the nitrogen cycle.

1 µm

cell wall

cell contents, or cytoplasm

1–3 µm

ENTEROCOCCUS FAECALIS

Normally a harmless inhabitant of the human digestive tract and vagina, this species can invade wounds and is resistant to many antibiotics.

0.5–1 µm

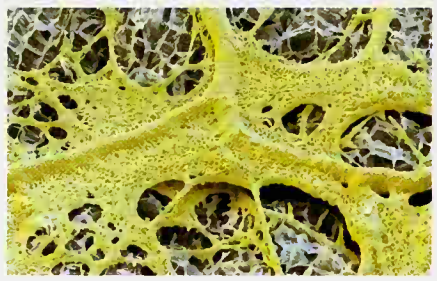
YERSINIA PESTIS

This species is the agent that causes bubonic plague. Transmitted to humans via fleas that live on rats, it causes up to 3,000 cases worldwide each year.

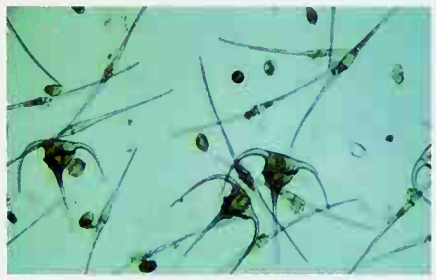
PROTISTS

From microscopic amoebae to giant kelp, the protists defy simple description, yet this informal grouping of eukaryotes included the first life forms to evolve that were more complex than the prokaryotes. It still produces most of Earth's food and oxygen.

DOMAIN	EUKARYOTA
KINGDOM	PROTISTA
CLADES	7
FAMILIES	About 778
SPECIES	About 70,500



In the slime molds, which are a group of amoebas, thousands of individual nuclei coexist within one giant cell.



Many single-celled protists have extraordinary shapes, such as these grapple-like dinoflagellates.

Some protoctists cause devastating disease, such as this *Giardia*, which infects intestines of humans and other animals.

DEBATE

MULTIPLE KINGDOMS

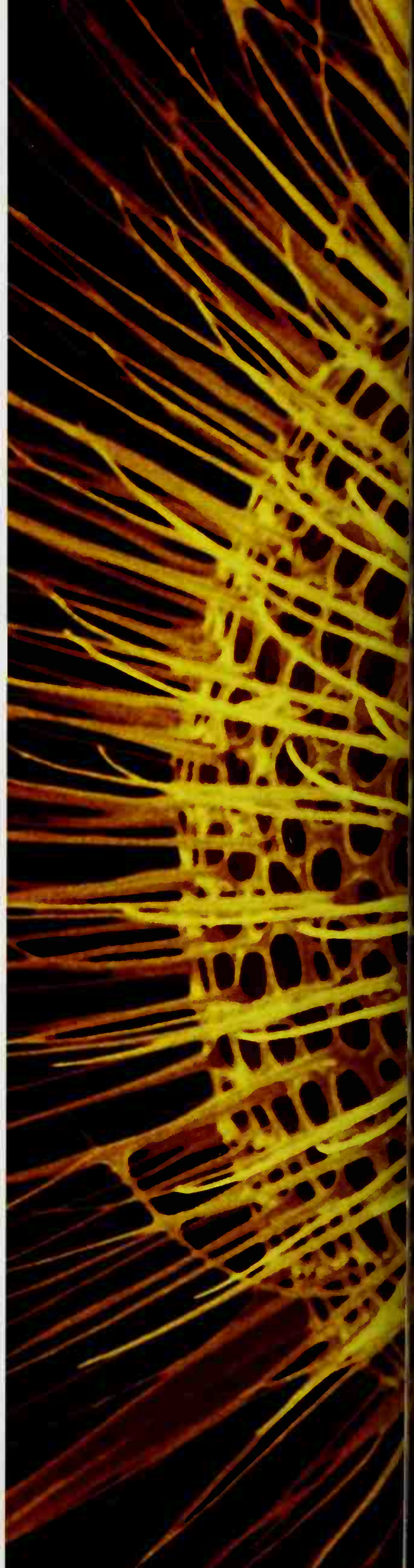
The kingdom Protista includes many organisms that are not classified as fungi, plants, or animals. And it includes many groups, ranging from single-celled amoebas to multicellular seaweeds, that are not closely related to one another. Many scientists think that Protista should be split into more than one kingdom.

Protists are mainly single-celled creatures that, unlike prokaryotes, have cell nuclei. Their basic cell nature separates them from the higher eukaryotes—plants, fungi, and animals—that later emerged from them. The protists include an incredible range of organisms with diverse lifestyles and ecological niches. Most are microscopic, ranging in size from 10 to 100 µm, and some are tiny enough to infest red blood cells. Others join together to produce multicellular colonies such as kelp, a seaweed that grows up to tens of feet in length, or the strange, funguslike slime molds, which form creeping puddles of slime that are essentially one giant cell. Typical protists include amoebae, which move around and capture food particles with their pseudopods (cell extensions), or plankton drifting in the sea, such as the beautiful diatoms, which have intricate silicon-based skeletons.

A HIDDEN REALM OF LIFE

Protists are among the most numerous creatures on Earth. Vast numbers of them live in the oceans and rivers, in sediments at the bottom of seas and lakes, and in the soil, while many spend all or part of their life cycles as parasites inside other organisms. They play a vital role in the planet's ecosphere, in particular as primary photosynthesizers, using the energy in light to convert carbon dioxide and water into food, while releasing oxygen into the atmosphere. They also act as predators and recyclers of matter. A few species are well known because they cause major diseases: the parasitic *Plasmodium* causes malaria, one of the biggest killers of humans; another parasite, *Trypanosoma brucei*, causes sleeping sickness. Also familiar are the dinoflagellates, a group of plankton organisms that can cause "red tides"—huge blooms of toxic creatures that kill fish and poison humans.

The taxonomy of the protists is complex because they don't form a natural kingdom. However, molecular and genetic analysis has allowed most protists to be placed in a few large clades, groups that each share a common ancestor: the amoebas and their relatives, the flagellates, the rhizarians, the alveolates, the heterokonts, and red and green algae.



MICROSCOPIC DEATH STAR >
The spines of this rhizarian are covered with a slime that has oozed from within its cell and is used to capture prey.

PROTIST GROUPS

The taxonomic groupings for the protists, which can be difficult to order, are new and evolving and can be subject to argument. The latest thinking is set out here.

AMOEBAS AND RELATIVES
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FLAGELLATES
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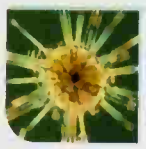

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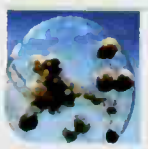

ALVEOLATES
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HETEROKONTS
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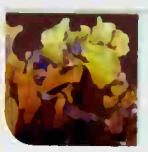

RED AND GREEN ALGAE
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AMOEBAS AND RELATIVES

Two of the protist clades, the Amoebozoa and the Opisthokonta, have evolved different ways of moving around and obtaining food.

Amoebas of the clade Amoebozoa can change shape by oozing projections of their single cells called pseudopods. They use these "false feet" to creep forward and hunt smaller organisms, enveloping victims within a sac of fluid and digesting them while still alive. Some amoebas are giant cells, and are just visible to the naked eye. A few are gut parasites, causing amoebic dysentery in humans. One group, the slime molds, have a remarkable strategy for avoiding starvation. When prey runs low their cells are attracted to one another by a chemical distress signal, and aggregate into a tiny creeping slug. This then sprouts upward a number of stalks, which burst to scatter spores. Each spore hatches into a new amoeba ready to hunt on new ground.

ANIMAL-FUNGUS ORIGINS

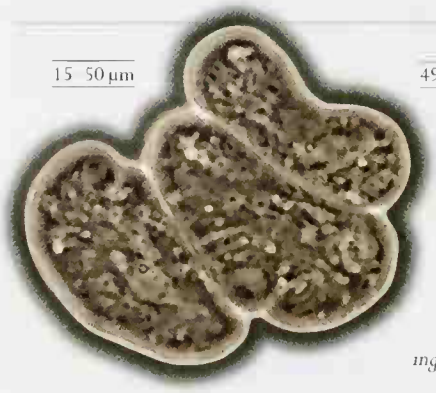
Most protists of the clade Opisthokonta have developed a single whiplike flagellum for propulsion in open water. Early in the history of life, some of these protists may have given rise to animals, and the single flagellum is still seen in the tail of animal sperm today. Others, called nucleariids, lost their flagellum and actually reverted to the amoeba-like state. The nucleariids may be closely related to fungi, as fungi also lack flagella and fertilize one another without the involvement of free-swimming sperm.

DOMAIN	EUKARYOTA
KINGDOM	PROTISTA
CLADES	2
FAMILIES	About 50
SPECIES	About 4,000

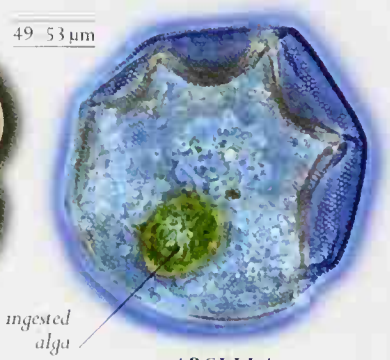
DEBATE

LIFE'S FIRST BRANCHES?

One theory of evolution says that the eukaryotes divided into two branches: unikonts (cells with one flagellum), such as opisthokonts, and bikonts (cells with two). Unikonts evolved into animals and fungi, while bikonts gave rise to plants. However, the DNA evidence for the theory is equivocal.



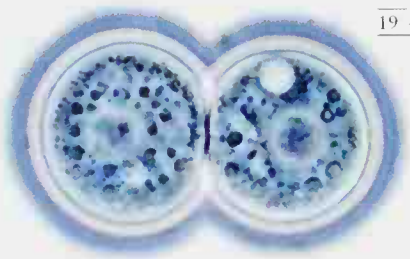
DYSENTERY AMOEBA
Entamoeba histolytica
This parasitic amoeba lives in the human intestine and can cause amoebic dysentery. It can contain up to eight nuclei.



ARCELLA BATHYSTOMA
This amoeba has a circular shell pitted with pores, domed on one side but sometimes with angular facets that develop into spines.

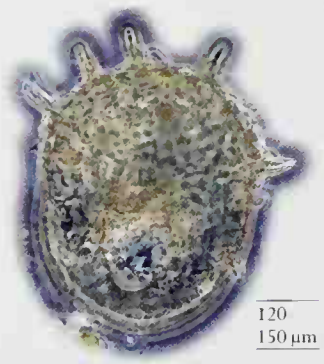
ARCELLA GIBBOSA
This amoeba has a yellow or brown, domed, circular shell, with an aperture in the flat side and a series of regular depressions on the dome.

ARCELLA DISCOIDES
This amoeba with two nuclei has a yellow-brown shell with a hole on one side through which pseudopods emerge.



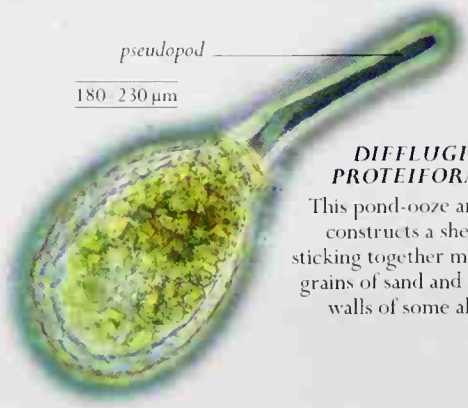
PROTACANTHAMOEBA CALEDONICA
Originally identified in a Scottish estuary, close relatives of this amoeba have been found in the liver of tench in the Czech Republic.

ARCELLA VULGARIS
Mainly found in stagnant water and soil, this amoeba has a convex shell, with a hole that allows pseudopods to emerge.



CENTROPYXIS ACULEATA
This amoeba lives on algae in lakes and marshes. It uses sand and the cell walls of some algae to make a shell with four to six spines.

***STEMONITIS* SP.**
This "chocolate tube" or "pipe cleaner" slime mold begins as a mass of cell content with many nuclei from which many spore-bearing stalks sprout up.



DIFFLUGIA PROTEIFORMIS
This pond-ooze amoeba constructs a shell by sticking together minuscule grains of sand and the cell walls of some algae.

SCALY NUCLEARIID
Pompholyxophrys ovuligera
Once assigned to the heliozoans clade, this flagellate of the Opisthokonta is covered in hollow scales or beads.

FLAGELLATES

The whiplike propulsion of single-celled organisms has evolved in several groups of protists, some unrelated. But it predominates in the flagellates.

Flagellates are powerful swimming microbes that move by the whiplike action of one or more threads called flagella. Many are predators, preying on smaller organisms such as bacteria. However, unlike changeable amoebas, these flagellates have a fixed, rigid shape and direct food into a cellular "mouth" at the base of their flagella. Remarkably, however, some, such as *Euglena*, have a degree of behavioral versatility that provides them with plant- and animal-type nutrition, depending upon circumstance. When exposed to bright light these organisms can photosynthesize; but in darkness their light-absorbing cell organelles, known as chloroplasts, shrivel and they revert to being a predator.

LIVING INSIDE ANIMALS

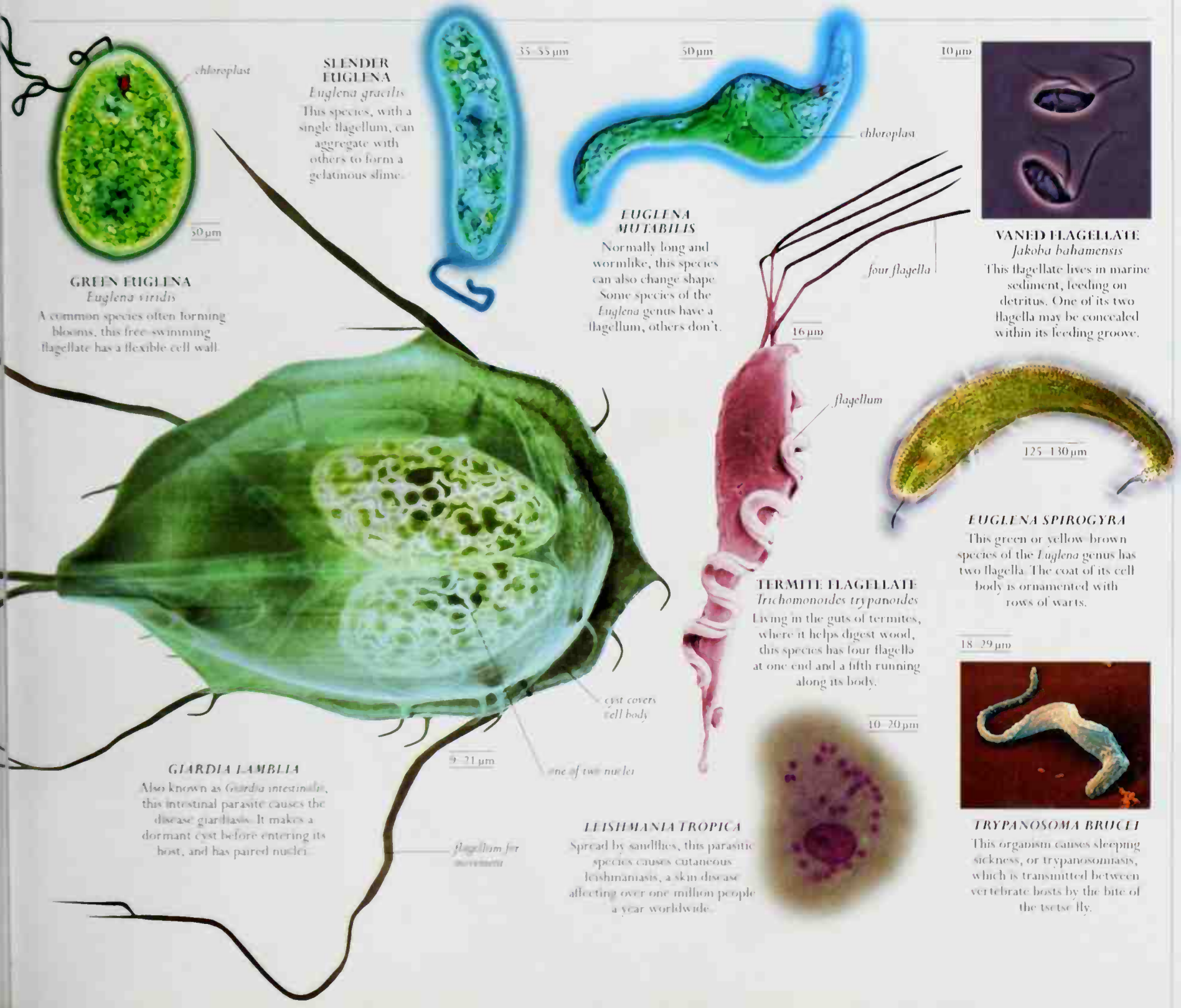
Many flagellates of this group lack the ordinary cellular features that would enable them to use oxygen in their respiration and survive inside the oxygen-poor environment of animal guts. Many are extraordinarily specialized, subsisting on the partially-digested food inside the abdomens of insects, but causing their host no harm. Others are parasites that cause devastating disease, in humans as well as other animals. One notorious group, the trypanosomes, are transmitted by biting insects and are responsible for sleeping sickness and leishmaniasis in the tropics.

DOMAIN	EUKARYOTA
KINGDOM	PROTISTA
CLADE	EXCAVATA
FAMILIES	40
SPECIES	About 2,500

DEBATE

EVOLUTION DOWN-SIZING

The flagellates inside termite guts lack mitochondria, the cell organelles that most other protists use to respire with oxygen. Some think these flagellates are very primitive protists. Others say they are more advanced organisms, and lost their mitochondria by evolving in an oxygen-poor environment.



GREEN EUGLENA
Euglena viridis
A common species often forming blooms, this free-swimming flagellate has a flexible cell wall.

SLENDER EUGLENA
Euglena gracilis
This species, with a single flagellum, can aggregate with others to form a gelatinous slime.

EUGLENA MUTABILIS
Normally long and wormlike, this species can also change shape. Some species of the *Euglena* genus have a flagellum, others don't.

VANED FLAGELLATE
Jakoba bahamensis
This flagellate lives in marine sediment, feeding on detritus. One of its two flagella may be concealed within its feeding groove.

TERMITE FLAGELLATE
Trichomonoides trypanoides
Living in the guts of termites, where it helps digest wood, this species has four flagella at one end and a fifth running along its body.

EUGLENA SPIROGYRA
This green or yellow-brown species of the *Euglena* genus has two flagella. The coat of its cell body is ornamented with rows of warts.

GIARDIA LAMBLIA
Also known as *Giardia intestinalis*, this intestinal parasite causes the disease giardiasis. It makes a dormant cyst before entering its host, and has paired nuclei.

LEISHMANIA TROPICA
Spread by sandflies, this parasitic species causes cutaneous leishmaniasis, a skin disease affecting over one million people a year worldwide.

TRYPANOSOMA BRUCEI
This organism causes sleeping sickness, or trypanosomiasis, which is transmitted between vertebrate hosts by the bite of the tsetse fly.

RHIZARIANS

The clade Rhizaria includes two phyla that are among the most beautiful of all of the miniature protists: the radiolarians and the forams.

The unique, intricately sculptured shells of both phyla make them distinctive members of the microscopic world, and some have left an impressive fossil record. Radiolarians build glassy shells with silica, stripping the ocean surface of this otherwise abundant mineral. Their body radiates long pseudopods that poke through their shells like the rays of the sun, supplemented in some by silica-hardened spines. Radiolarians use their pseudopods for catching food, but some also harbor living algae, gaining nourishment from the sugars their photosynthetic partners make as they drift in sunlit tropical oceans. Their silica dependence binds radiolarians to the sea, but their allies, the cercozoans, which include some amoebas, have also exploited soil and freshwater. Cercozoans typically retain the long pseudopods, but have shelled and shell-less forms, and some have flagella, depending on habitat demands.

The forams, or foraminiferans, have flourished in the oceans for hundreds of millions of years and their calcified shells litter the ocean floors to form layers of chalky sediment. Foram shells are so distinctive, even when fossilized, that geologists can use them to date deposits and identify hidden reservoirs of oil. When alive, each shell harbors a tiny amoeba that hunts with pseudopods—like the radiolarians—although some are big enough to catch animal larvae.

DOMAIN	EUKARYOTA
KINGDOM	PROTISTA
CLADE	RHIZARIA
FAMILIES	108
SPECIES	About 14,000

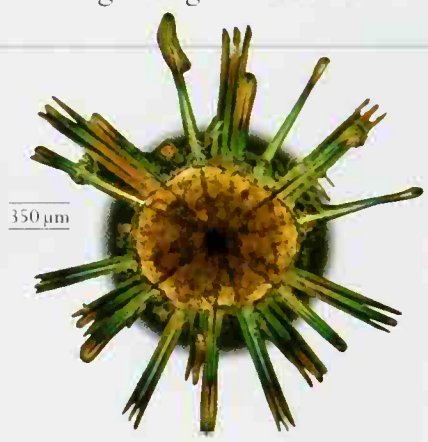
DEBATE

CONVERGING GIANTS

The pseudopods of radiolarians and forams mesh to form nets around their cells. This perhaps supports the idea that both forms descend from a common ancestor. But it is possible that this net evolved independently in the two groups, perhaps a result of both having large single cells.

LATTICE-SHELLED RADIOLARIAN
This radiolarian species of plankton belongs to the Spumellaria order, most of which have silica latticework skeletons.

100 µm



350 µm

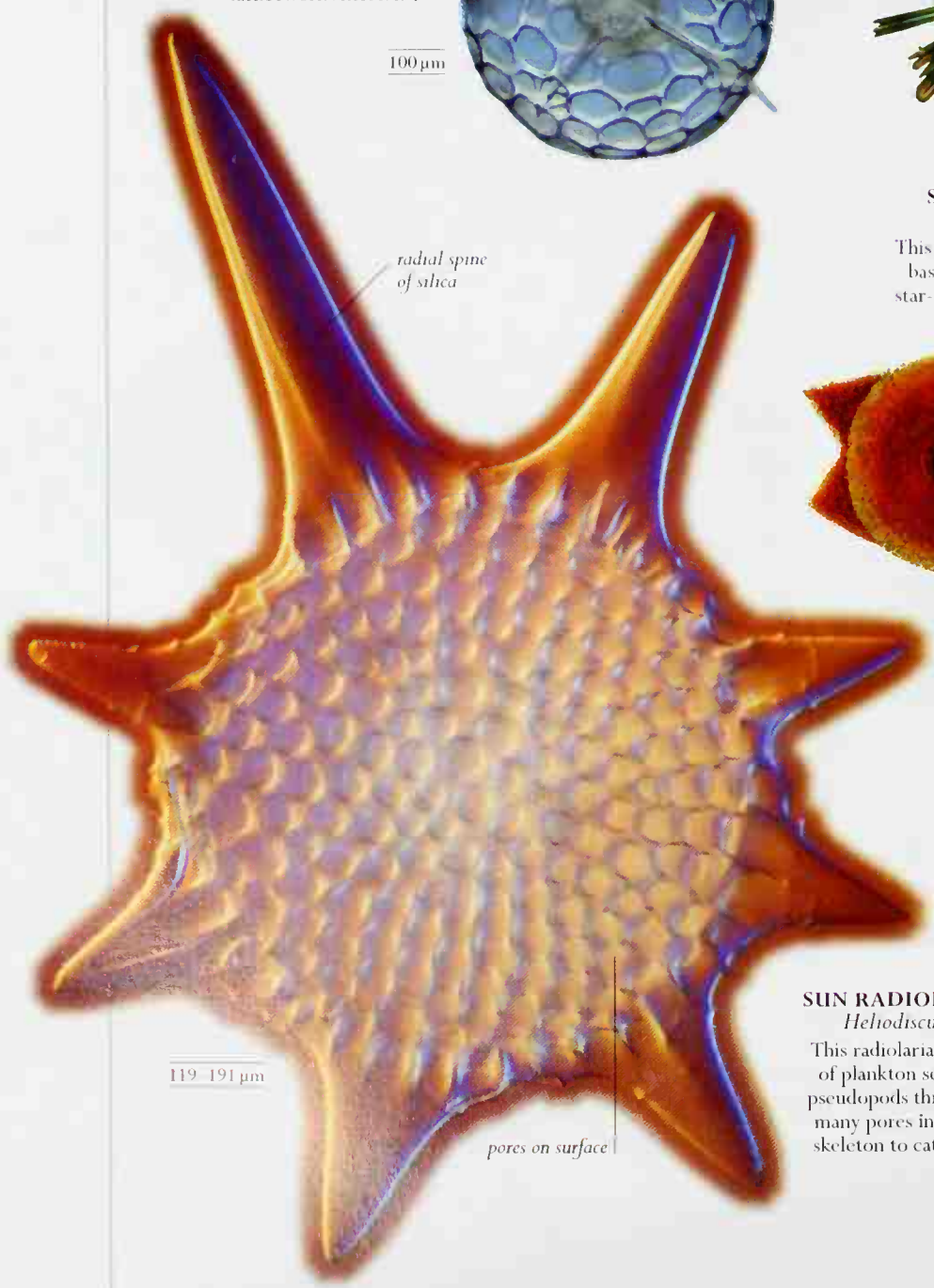
STAR RADIOLARIAN
Astrolithium sp.
This is characterized by fusing the bases of the radial spines into a star-shaped mass, or central body.

1/40 in
6 mm

SPHERICAL RADIOLARIAN
Physematium sp.
This cell surface of this species holds photosynthesizing organisms in a mesh of thin pseudopods.

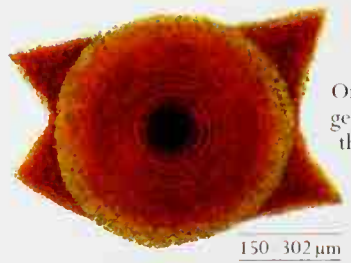
110 µm

DIDYMOCYRTIS TETRATHALAMUS
A living representative of an ancient fossil lineage, this radiolarian is named for its twin shells, which sometimes have hemispherical or conical caps.



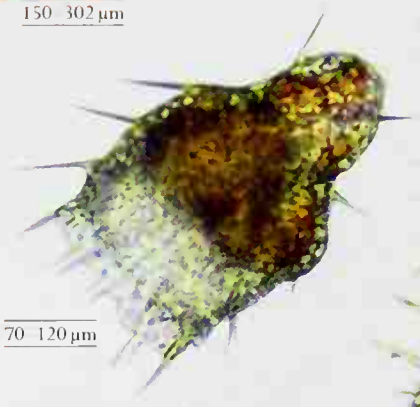
119–191 µm

SUN RADIOLARIAN
Heliodiscus sp.
This radiolarian species of plankton sends out pseudopods through the many pores in its silica skeleton to catch food.



150–302 µm

SPONGASTERICUS QUADRICORNIS
One of the radiolarians used by geologists to help date strata by the presence of its fossils, this species' name means "four-cornered."



70–120 µm

SPINY RADIOLARIAN
Lithomelissa setosa
This species displays the greatest seasonal variation of any radiolarian, making it a useful seasonal indicator in fossil and sedimentary records.

200–289 µm

THREE-ARMED RADIOLARIAN
Euchitonia elegans
This three-armed radiolarian forms a particularly spiny shell. Stiffened pseudopods emerge from shell pores.

20–32 µm

shell

captured cyanobacterium

OVAL-GREEN CERCOZOAN
Paulinella chromatophora
This freshwater shelled amoeba contains living cyanobacteria that can photosynthesize, providing the amoeba with food.

60–90 µm

protective lorica

ELEGANT CERCOZOAN
Clathrulina elegans
This species spends most of its life as an amoeba inside a perforated organic capsule, or lorica.

SPHAGNUM CERCOZOAN
Archerella flavum
This shelled amoeba lives in sphagnum wetlands. Its fossils are <8 mm used as indicators of past climate changes.

45–77 µm

nucleus

wall cell

6–7 µm

flagellum

***HELKESIMASTIX* SP.**
Using its flagellum, this species glides about preying on bacteria and even other species of the same genus.

40–150 µm

surface scales

SCALY CERCOZOAN
Euglypha sp.
This amoeba constructs oval-shaped shells from thin scales of silica, which fossilize well, making them objects of study for paleontologists.

rear flagellum

18–36 µm

flagellum lies ahead of body

LONG-FLAGELLATED CERCOZOAN
Cercomonas longicauda
This species moves using its two flagella, one of which trails behind the body, while the other lies ahead.

14 µm

pseudopod

chloroplast

GYMNOCHLORA STELLATA
Unlike many cercozoans, this species contains chloroplasts, which enable it to gain food by photosynthesizing in brightly lit waters.

"open "mouth"

35–102 µm

OVAL-SHELLED CERCOZOAN
Trinema sp.
This shell of this amoeba is open at one end, creating a type of mouth.

60–200 µm

YELLOW-SHELLED CERCOZOAN
Cyphoderia ampulla
This amoeba has a colorless or yellow shell composed of disk-shaped scales.

threadlike pseudopods radiate from cell

cell wall encrusted by protective layer of sand grains

pseudopod

20 µm

MARINE-GREEN CERCOZOAN
Chlorarachnion reptans
This contains characteristic cell organelles, which are tiny relics of a green alga it ingested in its early evolution.

0.46/.38 mm

GIANT CERCOZOAN
Gromia sphaerica
This species of cercozoan lives at the bottom of the ocean at the boundary between seawater and sediment. It feeds on organic detritus.

35–50 µm

SAND FORAM
Lithocolla globosa
This species of foram appears like a radiating sun. It builds up a protective layer of sand grains and other granules on the outside of its cell wall.

ALVEOLATES

Alveolates are united by possession of the same anatomical quirk—a fringe of tiny sacs around the cell called alveoli, after which the clade is named.

Three groups of superficially different but still single-celled protists are included in the alveolates: the dinoflagellates, the ciliates, and the apicomplexans. Predatory dinoflagellates swim in the ocean, using two whiplike flagella that emerge from grooves in their cell coat, running at right angles to one another. Some can discharge stinging barbs to immobilize their prey. Others release poisons, and sudden blooms of dinoflagellates are responsible for toxic red tides in parts of the world. A few are bioluminescent, sparkling with light when disturbed at night.

Most ciliates prowl on bacteria. Their smooth graceful motion is due to the coordinated beating of countless tiny hairs called cilia, which can cover their entire single-celled body. They also use these cilia to waft their food into a furrow that approximates to a mouth. Ciliates are virtually ubiquitous; some even live in the stomachs of mammalian herbivores, where they help digest the tough cellulose in plants.

In contrast, all apicomplexans are parasites. They are named for an arrangement of structures, called the apical complex, which helps them penetrate the living cells of animals, from which they derive their nourishment. Infamous among the apicomplexans are the malaria parasites, which penetrate the red blood cells of animals for food, destroying the cells in the process.

DOMAIN	EUKARYOTA
KINGDOM	PROTISTA
CLADE	ALVEOLATA
FAMILIES	222
SPECIES	About 20,000

DEBATE

PROTOZOANS

Early classifications placed food-eating microbes into different classes of the animal phylum Protozoa. Some microbes, such as the ciliates and the dinoflagellates, are now grouped together in modern protist taxonomy, although the exact nature of their relationships is debatable.

50–160 µm

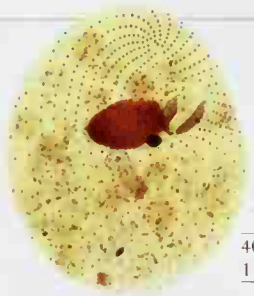
STALKED CILIATE
Vorticella sp.
This organism has an inverted bell-shaped body on a stalk, which is known to coil like a spring when stimulated.

1/10 in
2–3 mm

TRUMPET CILIATE
Stentor muelleri
This algae-feeding species, with a horn-shaped cell body, is large for a single-celled organism.

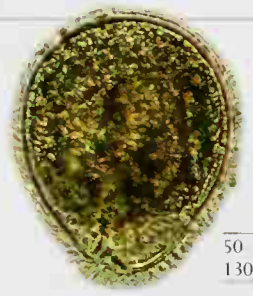
35
90 µm

SOIL CILIATE
Colpoda inflata
This normally kidney-shaped species plays an important role in soil ecology but is vulnerable to pesticides.



40
110 µm

POND CILIATE
Colpoda cucullus
Usually found in freshwater among decaying plants, this ciliate has food-containing organelles called vacuoles within its cell.

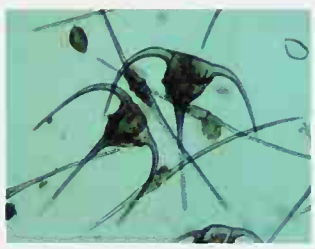


50
130 µm

GUT CILIATE
Balantidium coli
This is the only ciliate known to parasitize humans. Infection can cause intestinal ulcers, or serious intestinal infections.

6 µm

TOXOPLASMA GONDII
Passing between cats and other mammals (including humans), this parasite causes the disease toxoplasmosis, which is dangerous to the unborn human fetus.

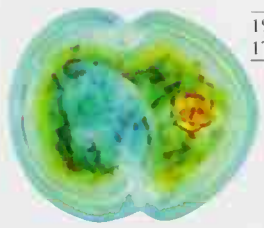


225 µm

THREE-HORNED DINOFLAGELLATE
Ceratium tripos
Among the most distinctive dinoflagellates, blooms of this plankton can cause dangerous red tides.

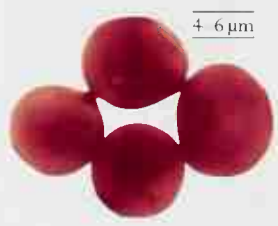
38–50 µm

CHAIN-FORMING DINOFLAGELLATE
Gymnodinium catenatum
This species of dinoflagellate forms long, swimming chains of up to 32 cells.



19
17 µm

MAHOGANY-TIDE DINOFLAGELLATE
Karlodinium veneficum
This dinoflagellate plankton can undergo a population explosion leading to "mahogany tides" that are lethal to fish.

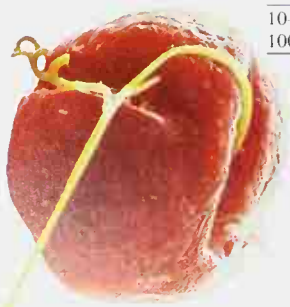


4–6 µm

CRYPTOSPORIDIUM PARVUM
This apicomplexan can cause cryptosporidiosis, a diarrheal disease transmitted by ingestion of its spores via feces, usually in contaminated water.

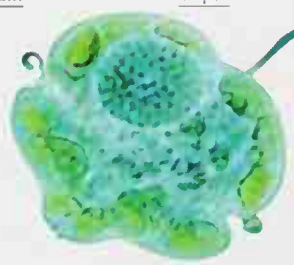
9–14 µm

PLASMODIUM FALCIPARUM
The most deadly of the malaria-causing *Plasmodium* species, this apicomplexan parasite is responsible for the deaths of over one million people a year worldwide.



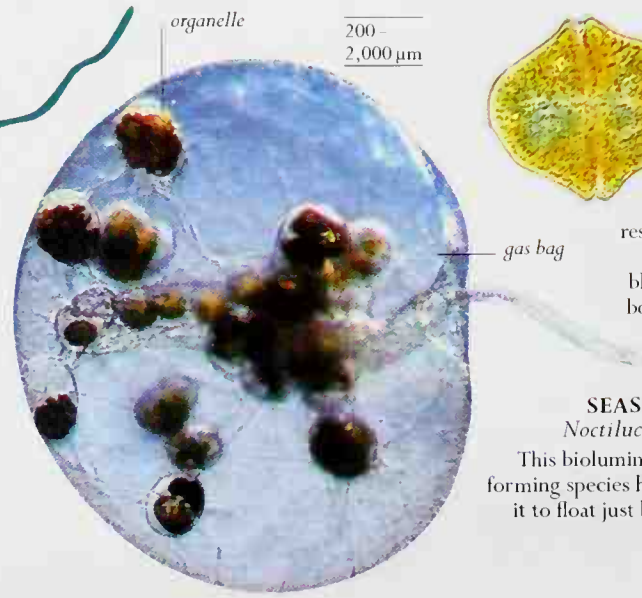
10–100 µm

***GYMNODINIUM* SP.**
Producing a neurotoxin, blooms of this dinoflagellate, found in both fresh- and saltwater, cause red tides and shellfish poisoning.



20–40 µm

KARENIA BREVIS
Formerly known as *Gymnodinium brevis*, this dinoflagellate plankton is a major cause of red tides in the Gulf of Mexico.



SEASPARKLE
Noctiluca scintillans
This bioluminescent, plankton-forming species has a gas bag allowing it to float just below the surface.

40–74 µm

AKASHIWO SANGUINEA
A large pentagonal species responsible for several recorded instances of harmful algal blooms, this dinoflagellate can both photosynthesize and prey on other plankton.

11–24 µm

AMPHIDINIUM CARTERAE
This plankton-forming species causes ciguatera, a fish poisoning that can cause human fatalities if contaminated fish are consumed.

HETEROKONTS

Heterokonts include some types of algae, which are photosynthesizing protists growing in or near water that do not have true leaves or roots.

Heterokonts are mostly defined as having two different types of flagella on the sperm they use in reproduction. One flagellum is covered in tiny, bristly hairs, or mastigonemes, and the other is smooth and whiplike. Heterokonts include diatoms and brown algae, as well as water molds. Diatoms are single-celled algae with finely sculptured silica walls divided into two parts called valves. They predominate in phytoplankton, plankton communities of small organisms that drift in open waters and engage in photosynthesis. Here, near the surface, their pigments absorb energy from sunlight to make food. Diatoms contain green chlorophyll—as do plants—but also a brown pigment called fucoxanthin, which serves to broaden the spectrum of light that can be used, making their photosynthesis significantly more efficient.

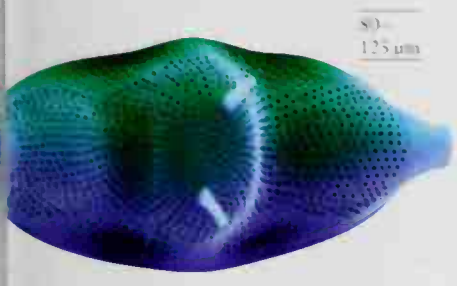
Brown algae occupy coastal habitats around the world. They also make use of fucoxanthin, and have evolved into complex multicellular seaweeds that superficially resemble a plant. Rather than true roots and leaves, their body consists of a holdfast for clasping to rock and a creeping thallus that lacks the internal veins of a true leaf. Nevertheless, some brown seaweeds, such as kelps, can grow to extraordinary lengths and make extensive underwater forests on some offshore coastlines.

DOMAIN	EUKARYOTA
KINGDOM	PROTISTA
CLADE	HETEROKONTOPHYTA
FAMILIES	177
SPECIES	About 20,000

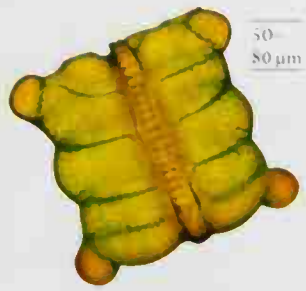
DEBATE

FROM ALGA TO MOULD

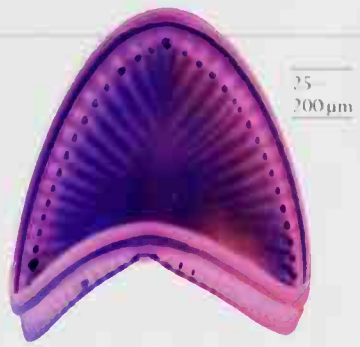
Water moulds grow and feed like mould, but unlike true moulds, which are fungi, have plantlike cell walls and heterokont flagella, while some also cause plant diseases. DNA analysis links them with diatoms and brown algae, so perhaps they evolved from algae that abandoned their chloroplasts and turned parasitic.



EPIPHYTIC DIATOM
Biddulphia sp.
The cause of brown film on fish tanks, in the wild this species grows on seaweed and rocks.



BARREL DIATOM
Biddulphia pulchella
This image clearly displays the different parts of a diatom: the two valves bound together by a narrow girdle.



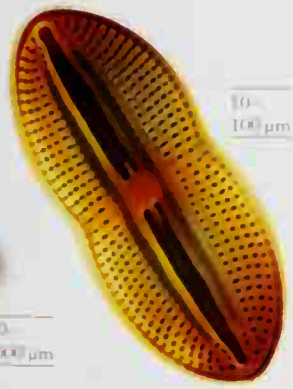
SADDLE DIATOM
Campylodiscus sp.
This genus of diatom shows a groove between the tubular lips, known as canals, around the edge of its valves.

COLONIAL DIATOM
Isthmia nervosa
This species grows on other algae, specifically seaweeds, forming branching colonies.

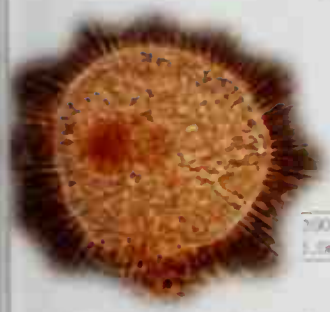
***GYROSIGMA* SP.**
The name of this diatom refers to the sigmoidal curve of its cell, meaning that it follows a very slight S-shape.

SLIMY DIATOM
Lyrella lyra
This secretes a gluey slime from its central groove to help the cells glide along their host's surface.

POND DIATOM
Pinnularia sp.
Two chloroplasts are visible in this pen-shaped diatom, found in ponds and wet ground.



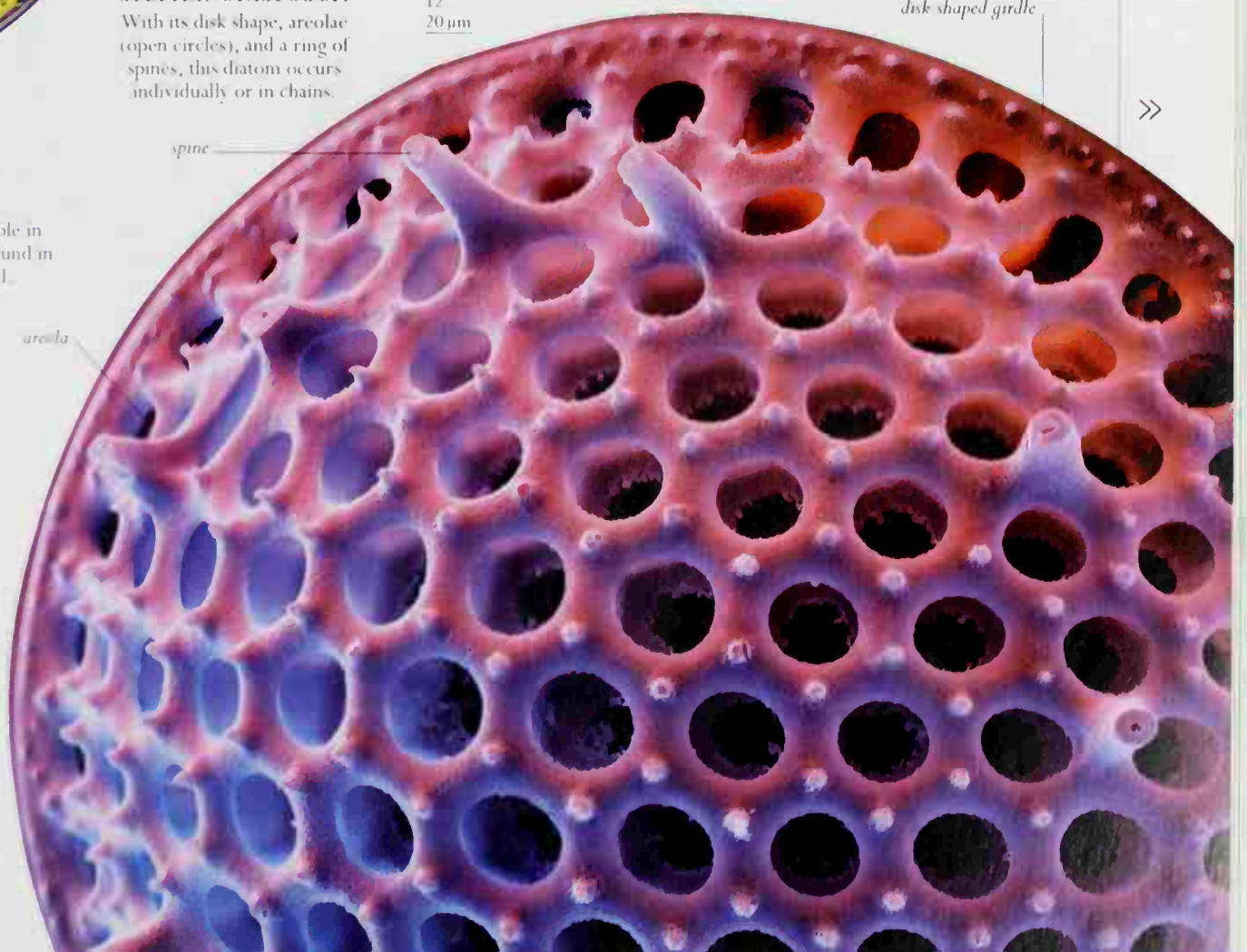
GROOVED DIATOM
Diploneis sp.
The valves of this species of diatom appear as two heavily pronounced lips, known as canals, on either side of a slitlike groove called a raphe.

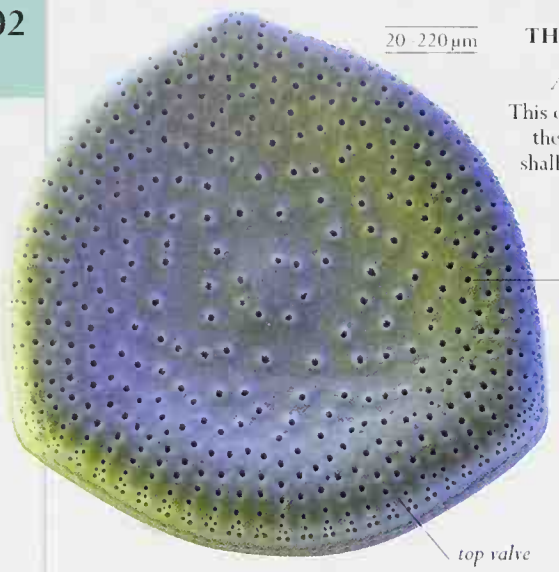


URCHIN HELIOZOAN
Actinophaerium sp.
This diatom resembles a sea urchin. It moves by shifting cell contents into its thin pseudopods.

***STEPHANODISCUS* SP.**
With its disk shape, areolae (open circles), and a ring of spines, this diatom occurs individually or in chains.

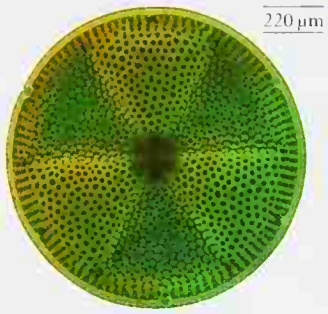
12–
20 µm





THREE-CORNERED DIATOM
Actinoptychus sp.
This diatom can be found in the neritic zone on the shallow continental shelf.

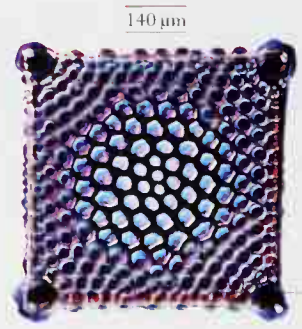
SPIDER'S-WEB DIATOM
Arachnoidiscus sp.
Strong radial ribs and web-patterned valves are features of this disk-shaped diatom. It can grow very large.



SUN-RAY DIATOM
Actinoptychus heliopelta
A distinctive pattern of alternating raised and depressed sectors on its top and bottom valves characterize this diatom species.

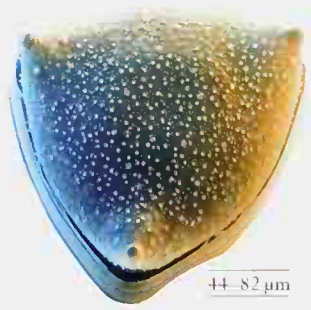
FIVE-ARMED DIATOM
Actinoptychus sp.
A five-arm appearance is produced by the alternating sectors on the valves of this species of the *Actinoptychus* genus.

***TRICERATIUM* SP.**
More than 400 species of this genus of marine diatom are known. Diatoms of this genus are often, but not always, three sided.



TRICERATIUM FAVUS
The heavily silicified cell walls of this species can leave a trail of silica in the water as it moves. This can show how seawater penetrates into freshwater environments.

BOAT-SHAPED DIATOM
Navicula sp.
This species belongs to the largest genus of diatom, with thousands of species known.



DAPPLED DIATOM
Stictodiscus sp.
Seen under a scanning electron microscope, this diatom shows pores dappled on its valve surface, above a surrounding girdle.

THONGWEED
Himanthalia elongata
During its reproductive phase, this brown seaweed of the Northern Hemisphere produces long straplike fronds, which are types of divided leaves.

TOOTHED WRACK
Fucus serratus
This robust, shrubby, olive-brown seaweed grows on lower shores all round the North Atlantic.

SUGAR KELP
Saccharina latifolia
Found on rocky shores and at depths of 26–98 ft (8–30 m) in northern seas, this brown seaweed is also often known as sugar wrack.

CUVIE
Laminaria hyperborea
This algae is commercially important in iodine production. It grows at depths of 26–98 ft (8–30 m), mainly in the Northern Hemisphere.

WIREWEED
Sargassum muticum
Originally from Japan, this invasive brown seaweed has now spread to Europe. It can grow as much as 4 in (10 cm) in a day.

SEA OAK
Halidrys siliquosa
A large brown seaweed, common in rock pools in Europe, this species has a distinctive zigzag stem and air-filled pods known as air bladders.

RED AND GREEN ALGAE

Red and green algae are among the largest protists. While red algae have a high diversity in the sea, green algae do better in freshwater.

Although some are microscopic organisms, the most familiar red algae grow as multicellular seaweeds. They have evolved an extraordinary diversity of forms, ranging from rock-hugging encrustations that look more like lichens to bristly or leafy clumps. Like plants, most algae on land or in water use green chlorophyll during photosynthesis to catch the energy of sunlight to make food. But red algae have pigments that allow them to do the same thing in deeper coastal waters. In this environment a combination of pigments enables them to absorb the little blue light that penetrates the sea at such depth. This means that red algae can live much deeper in the oceans than the brown and green seaweeds.

FROM POND TO LAND

Green algae can be found in marine shallows, freshwater ponds, and streams, and form most of the photosynthesizing plankton there. They are also found on land, where some species form green mats that, for instance, coat the surfaces of tree trunks. Many share the same chlorophyll pigments that occur in land plants. While green algae typically produce sperm with two identical flagella, they also have spore-producing stages in their life cycle. Since simple plants have sperm- and spore-producing stages, the common ancestor of all true plants was a green alga.

DOMAIN	EUKARYOTA
KINGDOM	PROTISTA
CLADE	ARCHAEPLASTIDA
FAMILIES	181
SPECIES	About 10,000

DEBATE

CLOSE RELATIVES?

Plants conquered the land far better than any alga, but one group of green algae, the stoneworts, may be their cousins. Stoneworts are rooted in mud by cell filaments called rhizoids, similar to roots in simple plants. Their reproductive structures and branches are similar to those of plants too.

RED ALGAE

There are about 6,000 species of red algae. Unlike brown and green algae, they do not produce flagellated sperm. Instead, reproduction involves a fusion of cells more reminiscent of that in fungi. Some red algae become calcified, forming colonies. And, in spite of their name, red algae pigments make them red, olive, or gray.

DULSE
Palmaria palmata
In North Atlantic coastal communities, this is a traditional source of protein and vitamins.

CORAL WEED
Corallina officinalis
This red seaweed is common in rock pools worldwide, forming branching, featherlike fronds.

EYELASH WEED
Calliblepharis ciliata
This northern hemisphere seaweed has flat fronds, fringed with numerous "branchlets."

GRACILARIA FOLIIFERA
Rising as slender dull purple stems, this red seaweed branches sparsely to give straplike fronds. It grows abundantly in shallow lagoons worldwide.

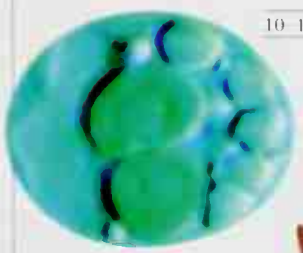
GRACILARIA BURSA-PASTORIS
A long, thin red seaweed with forked or alternating branches, this species is found from southern England to the Pacific and the Caribbean.

AGARDHIELLA SUBULATA
Originally from the western Atlantic, Caribbean, and Gulf of Mexico, this fleshy red alga has invaded some parts of Europe.

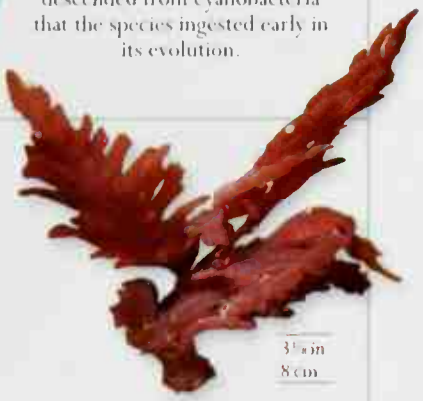
MASTOCARPUS STELLATUS
This red seaweed has conspicuous papillae, which are reproductive bodies, on the fronds. It is found in the North Atlantic.

GLAUCOPHYTES

Glaucophytes are little more than bags of simple chloroplasts known as cyanelles. A freshwater group, they are sparsely but widely distributed around the world.



CYANOPHORA PARADOXA
Like other glaucophytes, the cyanelles of this species may have descended from cyanobacteria that the species ingested early in its evolution.



SCHMITZIA HISCOCKIANA
Found in areas swept almost bare by the tide, this red seaweed is fleshy and gelatinous, with flattened branches and fingerlike projections.

MAERL
Phymatolithon calcareum
This species, an encrusting coralline alga of the British Isles, is commercially dredged and ground up as a calcium-rich soil additive.

»

» RED ALGAE

8 in
20 cm

PTEROCLADIELLA CAPILLACEA

With feathery branches that taper toward the tip, this red seaweed, found in pools worldwide, often develops a Christmas tree appearance.

6 in
15 cm

BUSH WEED
Ahnfeltia sp.

A source of the gelatinous substance agar, used in petri dishes, this Northern Hemisphere seaweed forms dense tufts of fronds.

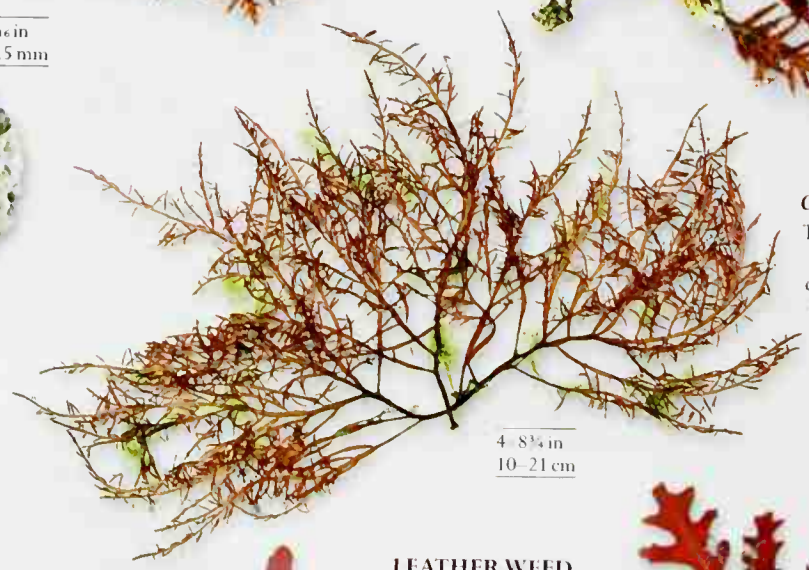
MELANAMANSIA FIMBRIFOLIA

Found in North America and Australia, this seaweed grows on sediment-covered reefs at depths of up to 180 ft (55 m).

1/16 in
2.5 mm

SPOROLITHON PTYCHOIDES

This red algae forms a crust using calcareous deposits in its cell walls. It is found worldwide in rocky, current bottoms and coastal pools.



4–8¾ in
10–21 cm

CHONDRIA DASYPHYLLA

This species, found worldwide, has feathery fronds ending in clublike branchlets that sprout spore-bearing branchlets and urn-shaped fruit bodies.

12 in
30 cm

CERAMIUM VIRGATUM

This small red seaweed grows worldwide on rocks and other seaweeds. From a tiny holdfast it grows into filament-like fronds with forked tips.

8 in
20 cm

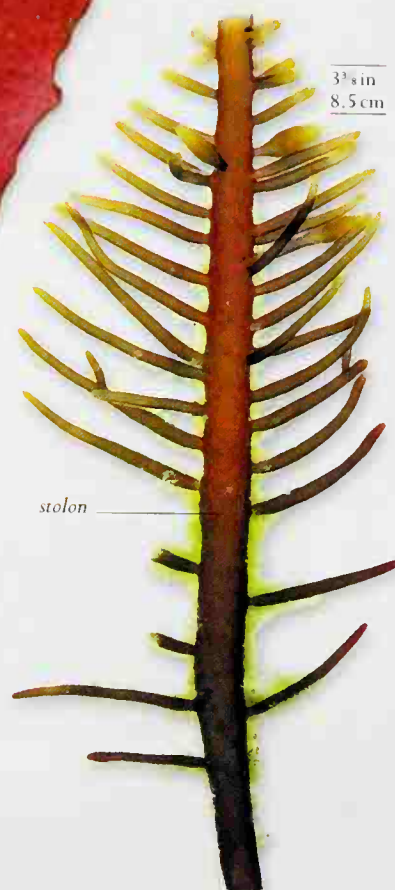
BROAD WEED
Lenormandiopsis nozawae

On both sides of this broad-bladed seaweed, found in temperate areas, are clusters of spore-bearing bodies, themselves home to tiny parasitic algae.

LEATHER WEED
Ptilophora leliaertii

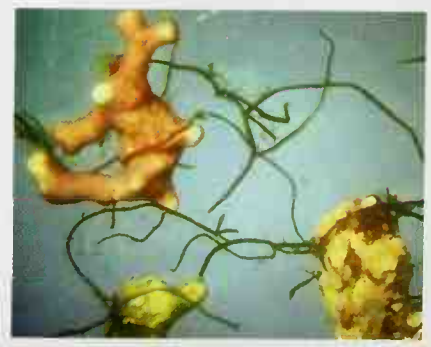
First described in 2004 after it was discovered on a reef off the coast of South Africa, this red seaweed has feathery compound branches.

14 in
35 cm



GELIDIELLA ACEROSA

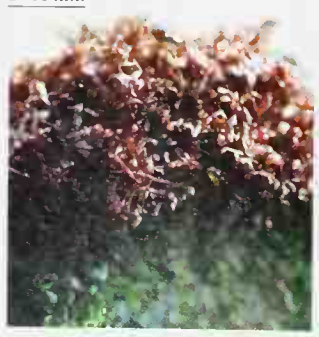
An important source of agar, this red seaweed, found in India, has a slender, cylindrical shoot, known as a stolon.



1⅛ in
3 cm

GELIDIELLA CALCICOLA

This small seaweed of the British Isles creeps over the surface of rock. Irregular branches project up and form tufts. It also grows on algae, particularly maerl.



1/16–⅝ in
2–15 mm

GELIDIUM PUSILLUM

Growing worldwide from an extensive creeping base that incorporates shells and small snails, this turf-forming red seaweed has flattened, leaflike fronds.

12 in
30 cm

SEA BEECH
Delesseria sanguinea
Known for its characteristic beechlike leaves, this red seaweed grows in the understory of kelp forests in Europe.

BLACK CARRAGEEN
Furcellaria lumbricalis
This Northern Hemisphere seaweed has cylindrical, brown-black fronds that branch into masses of fleshy fingers.

LAURENCIA OBTUSA
This tropical species is a source of halogenated terpenoids—chemical defenses against grazing crabs and urchins—which also make useful antifouling agents.

2½–8¾ in
7–22 cm

8¾ in
22 cm

IRISH MOSS
Chondrus crispus
Also known as carrageen moss, this seaweed of the British Isles is important as a source of carrageen, which is a gelling agent.

12 in
30 cm

2–10 cm
¾–4 in

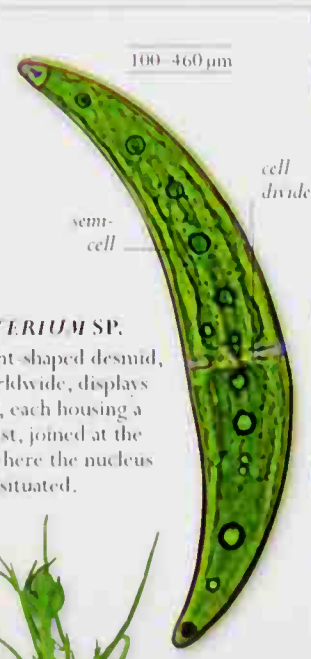
POLYSIPHONIA LANOSA
Growing on other seaweeds in tufts like pom-poms in the Northern Hemisphere, this red alga has branching filaments made up of long tubular cells.

350 µm

***MICRASTERIAS* SP.**
This desmid, found in temperate areas, has multiple spined arms, tipped with prongs that allow the semicells to interlock.

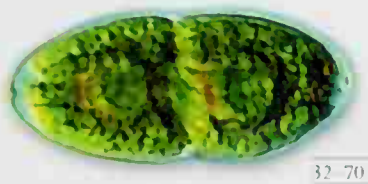
GREEN ALGAE

Green algae include desmids, which typically have a single cell divided into two symmetrical semi-cells. They also include multicellular green seaweeds, such as sea lettuce, and pond weeds, such as stonewort, a close relative of land plants. Some species are also adapted to resist dessication and thrive on land.



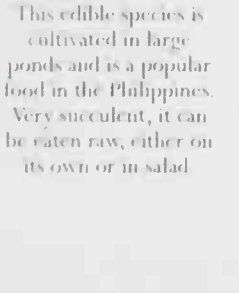
100–460 µm

***CLOSTERIUM* SP.**
This crescent-shaped desmid, found worldwide, displays semicells, each housing a chloroplast, joined at the isthmus, where the nucleus is situated.



32–70 µm

***PENIUM* SP.**
This desmid green alga, found in North America, is symmetrically divided into cylindrical semicells with blunt, oval ends and girdle bands.



SEA GRAPE
Caulerpa lentillifera
This edible species is cultivated in large ponds and is a popular food in the Philippines. Very succulent, it can be eaten raw, either on its own or in salad.

4¾–23⅝ in
12–60 cm

SEA LETTUCE
Ulva lactuca
A popular food worldwide, this green alga has broad, crumpled fronds, anchored to rock by a holdfast. It can also form floating communities.

12–47 in
30–120 cm

NITELLA TRANSLUCENS
This algae is part of the Charales order, the closest algal relatives of land plants. It thrives in wet, acidic conditions near peat bogs.

20 in
50 cm

COMMON STONEWORT
Chara vulgaris
Also known as skunkweed, this Charales algae of the Northern Hemisphere emits an unpleasant smell.

¾–3½ in
2–8 cm

PLANTS

» 108
LIVERWORTS
The simplest true plants, liverworts are typically small and ribbonlike, or straggling, with tiny leaves. They do not have flowers, and spread by shedding spores instead of making seeds.

By harnessing the energy in sunlight, and using it to grow, plants play a central role in life on Earth. They generate food for animals and other organisms, and often form their habitats as well. Some plants are small and simple, but they also include giant conifers, and a dazzling wealth of flowering species that have evolved a remarkable array of shapes and strategies for survival.

» 110

MOSSES

Widespread in damp, cool, and shaded places, mosses are nonflowering plants that have wiry stems and small, spirally-arranged leaves. Many mosses grow on bare rocks and on trees.

» 112

FERNS AND RELATIVES

Ferns are the largest plants that reproduce with spores instead of seeds. Many are low-growing, but some form trees, which have trunks made of fibrous roots rather than wood.

» 116

CYCADS, GINKGOS, AND GNETOPHYTES

These plants do not have flowers, but they do form seeds. Before flowering plants evolved, cycads formed an important part of the world's vegetation.

» 118

CONIFERS

Although far fewer in species than flowering plants, conifers dominate the landscape in some parts of the world. All of them are trees or shrubs, and they typically form seeds in woody cones.

» 122

FLOWERING PLANTS

This is by far the largest group of living plants, making up the bulk of the world's vegetation. They all grow flowers—often inconspicuously—and spread by forming seeds.

LIVERWORTS

Found mainly in damp, shaded habitats, the liverworts are thought to be the simplest of all the existing groups of land plants. They come in two distinct forms: some are flat and ribbonlike; others are more like mosses, with slender stems flanked by tiny leaves.

DIVISION	MARCHANTIOPHYTA
CLASSES	3
ORDERS	13
FAMILIES	86
SPECIES	8,000

DEBATE

PLANTS APART

Liverworts are traditionally classified with mosses and hornworts in a group of ancient plants known as the bryophytes. All three have a number of things in common, but liverworts have some unique features that set them apart from the other two. They are the only land plants without stomata, or adjustable breathing pores, during their sporophyte (spore-producing) stage. Also, their rhizoids, or hairlike roots, each contain just one cell. As a result, they are now classified in a division of their own, the Marchantiophyta.

Ribbonlike liverworts are unlike all other plants. Instead of stems and leaves, they have a flat body, or thallus, that repeatedly forks as it grows. Many species have a glistening upper surface with deeply divided lobes. Medieval herbalists noted this liverlike shape, giving these plants their common name. Superficially, leafy liverworts are quite different, with trailing or spreading stems. They usually have two ranks of leaves, and a third row of much smaller leaves on their underside. Some kinds form loose mats in damp grass, but they also grow on rocks and on trees. They are much more numerous than ribbonlike liverworts, particularly in the tropics, where many species live epiphytically, creeping across the shaded leaves of rain forest trees.

Unlike many flowering plants, liverworts have no preset limits to their growth. Most are less than ¾ in (2 cm) high but may keep spreading for years, forming fragmented patches several yards (meters) across. This fragmentation gradually creates new plants. In addition, some species produce clusters of cells, called gemmae, in depressions on their upper surface. Scattered by raindrops, gemmae grow into new plants.

FORMING SPORES

Liverworts also reproduce by scattering spores, microscopic cells that form new plants. Spore formation requires damp conditions, because a liverwort's female cells must first be fertilized by swimming male sperm. In some species, male and female cells are produced by the same plant, but in many, the sexes are separate. Sperm cells often reach egg cells with the help of raindrops, which splash them from one plant to another.

Many liverworts produce sperm or egg cells in structures that look like tiny umbrellas or parasols. After fertilization has taken place, the spores develop and are then scattered into the air.

v SEPARATE SEXES IN THE COMMON LIVERWORT
These parasol-shaped structures produce male sex cells. Female sex cells are produced by separate plants.

SNAKEWORT
Conocephalum conicum
F: Conocephalaceae

Found worldwide on streamside rocks and in other wet places, this ribbon-shaped liverwort has a glossy upper surface, flecked with minute translucent air chambers.

CRESCENT-CUP LIVERWORT
Lunularia cruciata
F: Lunulariaceae

Common in gardens and greenhouses, this ribbon-shaped liverwort is bright green, with distinctive reproductive structures, gemma cups, that look like tiny fingernails.

COMMON LIVERWORT
Marchantia polymorpha
F: Marchantiaceae

In spring and summer this ribbon-shaped liverwort produces conspicuous spore-forming structures that look like tiny parasols. It is widespread in damp habitats and gardens.

CRYSTALWORT
Riccia fluitans
F: Ricciaceae

This variable liverwort has two forms—one grows on wet mud, while the other floats in ponds. Both have narrow ribbonlike stems that fork frequently.

OVERLEAF PELLIA
Pellia epiphylla
F: Pelliaceae

Growing on wet peat and rocks, this ribbon-shaped liverwort often forms a tufted mat. It produces black spore capsules on slender white stalks.

TAMARISK SCALEWORT
Frullania tamarisci
F: Frullaniaceae

Colored a distinctive purplish brown, this leafy liverwort forms mats on tree trunks and rocks. Its main leaves have small concave lobes that hold water.

GREATER WHIPWORT
Bazzania trilobata
F: Lepidoziaceae

A native of damp woodlands, this mound-forming liverwort has main leaves that overlap and curve downward, giving its stems a caterpillar-like shape.

WALL SCALEWORT
Porella platyphylla
F: Porellaceae

This densely branched, leafy liverwort grows in a wide variety of habitats, from woodlands to walls. Its main leaves overlap like a set of scales.

COMPRESSED FLAPWORT
Nardia compressa
F: Jungermanniaceae

A leafy liverwort growing by mountain streams, this species often forms extensive mats of overlapping stems. It has two main ranks of rounded leaves, pressed together.

EVEN SCALEWORT
Radula complanata
F: Radulaceae

Ranging in color from light green to brown, this scaly-leaved liverwort creeps over flat, brightly lit surfaces as varied as tree trunks and coastal rocks.

GREATER FEATHERWORT
Plagiochila asplenioides
F: Plagiochilaceae

A delicate liverwort with translucent leaves, this species forms spreading noodlelike tufts. It grows on shaded rocks and soil, particularly on chalk and limestone.

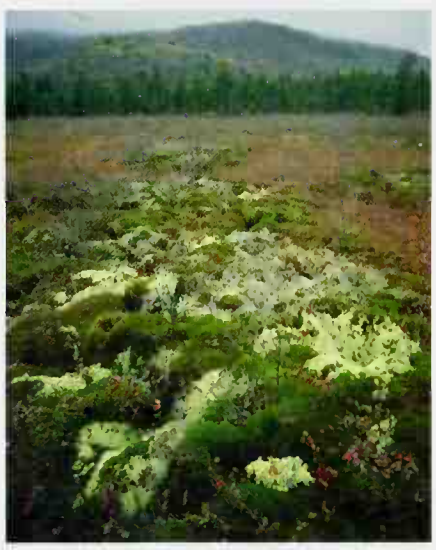
VARIABLE-LEAVED CRESTWORT
Lophocolea heterophylla
F: Geocalycaceae

Found on decaying logs and tree stumps, this translucent, leafy liverwort has two ranks of main leaves, with rounded or toothed tips. It produces black spore capsules on white stalks.

MOSSES

Mosses are nonflowering plants that typically form mats or cushion-shaped clumps. Despite their small size, they are remarkably resilient plants. They are able to grow in a wide range of habitats, from woodlands to deserts, and are found on every continent, including Antarctica.

DIVISION	BRYOPHYTA
CLASSES	8
ORDERS	26
FAMILIES	118
SPECIES	12,000



In the far north sphagnum mosses form raised bogs—here interspersed with gray patches of reindeer moss lichen.

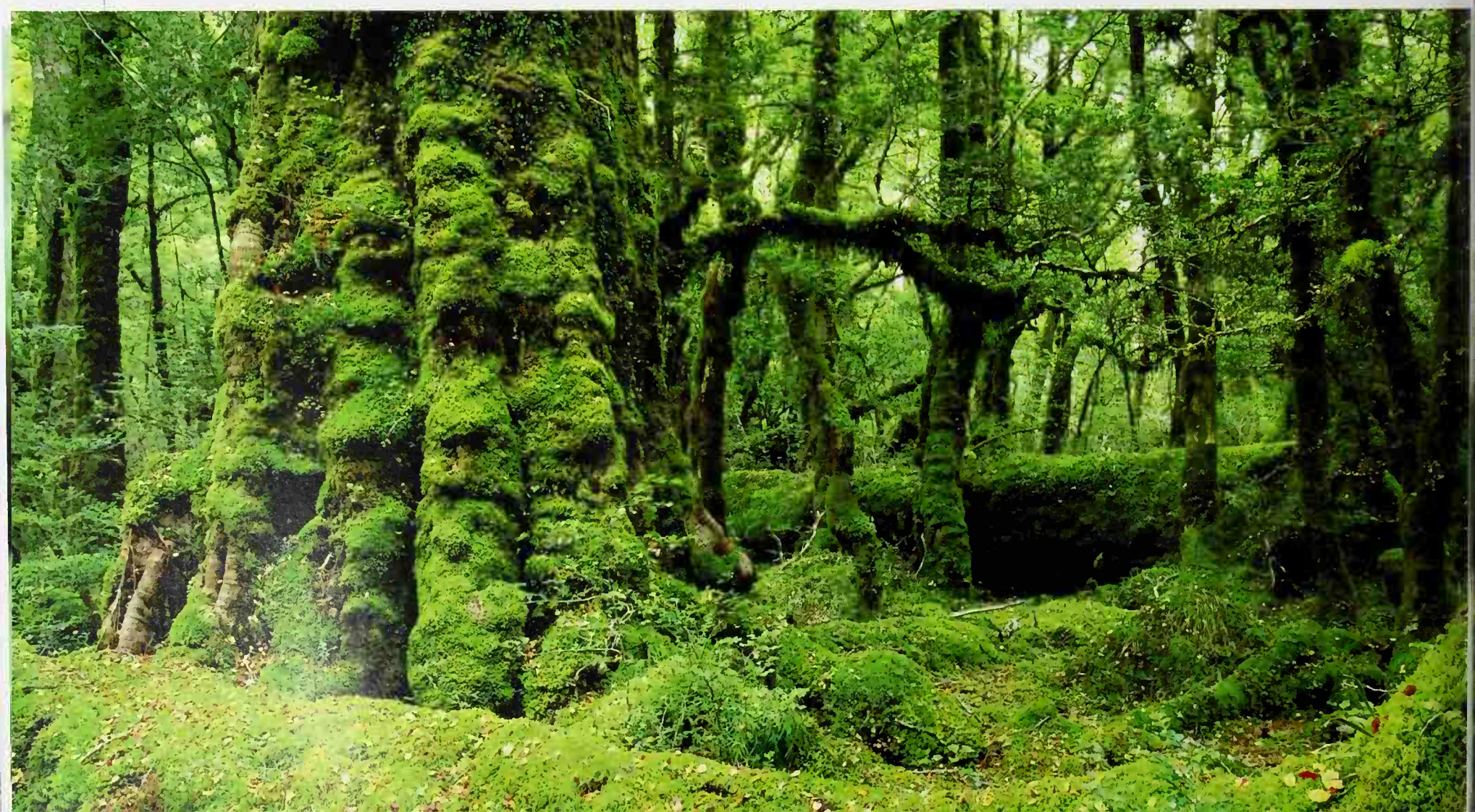
Mosses have thin leaves that usually spiral around slender, wiry stems, and they reproduce by scattering spores. Like liverworts, they need moist conditions to grow. They can be extremely abundant in habitats that are always damp, and some species—particularly sphagnum mosses—form extensive blankets, dominating the ground in cold parts of the world. Others, however, are able to remain dormant during droughts. They look gray and lifeless, but become green again within minutes if it rains.

Mosses have a two-stage life-cycle—a feature shared by all other plants. In mosses, the dominant stage is the gametophyte, which produces male and female cells. After the female cells are fertilized, they produce the spore-forming stages or sporophytes, which remain attached to the parent plant. Most moss sporophytes have a capsule on the end of a long stalk. Once ripe—a process that can take many months—the capsule splits open, releasing up to 50 million spores into the air.

Because moss spores are so small and light, they are carried great distances by the slightest breeze. This makes mosses very good at dispersing and enables them to colonize all kinds of microenvironments, from crevices in the bark of trees to damp walls and roofs.

MOSS LOOKALIKES

Several plants commonly known as mosses do not belong to this group. Club mosses are more complex than true mosses, and have more robust stems and leaves. Living species are typically less than 20 in (50 cm) high, but in prehistoric times, club mosses included treelike forms up to 130 ft (40 m) high. Other moss lookalikes include reindeer moss—actually a form of lichen—and Spanish moss, a flowering plant in the bromeliad family that grows hanging from tree branches.



v DEEP COVER
The cool, moist climate in New Zealand's Fjordland National Park creates perfect conditions for a wide variety of mosses.

1¼ in/3 cm

BLACK ROCK MOSS
Andreaea rupestris
F: Andreaeaceae

Widespread on mountains, this dark-colored moss grows on bare rock. Unlike most mosses, its capsules release their spores through four microscopic slits.

1¼ in/3 cm

FIRE MOSS
Ceratodon purpureus
F: Ditrichaceae

Found worldwide, particularly on burned or disturbed ground, this low-growing moss is also common on roofs and walls. It produces a dense carpet of spore capsules in spring.

¾ in/2 cm

COMMON POCKET MOSS
Fissidens taxifolius
F: Fissidentaceae

This widespread moss has short, spreading stems bearing two ranks of pointed leaves. It grows in shaded ground and on rocks.

VELVET FEATHER-MOSS
Brachythecium velutinum
F: Brachytheciaceae

With its much-branched stems, this abundant moss forms creeping mats on dead wood and in poorly drained grass. It has a worldwide range.

spore capsules with conical lids

4 in
10 cm

6 in/15 cm

WHITE FORK MOSS
Leucobryum glaucum
F: Dicranaceae

Growing in large, neatly rounded cushions, this woodland moss has a characteristic gray-green hue, turning almost white in dry weather.

2 in/5 cm

MOUNTAIN FORK MOSS
Dicranum montanum
F: Dicranaceae

A moss that forms compact feathery mounds, this species has narrow leaves that curl up when dry, often breaking off to form new plants.

2 in/5 cm

COMMON TAMARISK MOSS
Thuidium tamariscinum
F: Thuidiaceae

Its finely divided "fronds" make this woodland moss resemble a miniature fern. It grows on rotting wood and rocks in Europe and northern Asia.

1¼ in
3 cm

CYPRESS-LEAVED PLAIT MOSS
Hypnum cupressiforme
F: Hypnaceae

This highly variable mat-forming moss has crowded, overlapping leaves. Found worldwide, it is common on rocks and walls, and beneath trees.

4 in
10 cm

OSTRICH-PLUME FEATHER MOSS
Ptilium crista-castrensis
F: Hypnaceae

Found mainly in northern forests, this moss has feather-shaped, symmetrically branched stems, often forming extensive patches below spruces and pines.

32 in
80 cm

WILLOW MOSS
Fontinalis antipyretica
F: Fontinalaceae

A submerged freshwater species, willow moss trails from rocks in slow-flowing rivers and streams. It has three rows of keeled, dark green leaves.

1¼ in/3 cm

PURPLE FORK MOSS
Grimmia pulvinata
F: Grimmiaceae

Growing on rocks, roofs, and walls, this widespread moss has leaves that end in long silvery hairs. Its spore capsules grow on curved stalks.

3¼ in
8 cm

SWAN'S-NECK THYME MOSS
Mnium hornum
F: Mniaceae

Brilliant green in spring, this is a common woodland moss in North America and Europe. Its spore capsules have curved stalks resembling a swan's neck.

spore capsules are horizontal when ripe

¾ in/1 cm

CAPE THREAD-MOSS
Orthodontium lineare
F: Orthodontiaceae

This moss from the Southern Hemisphere was introduced to Europe in the early 20th century and has become an invasive species.

10 in
25 cm

BLUNT-LEAVED BOG MOSS
Sphagnum palustre
F: Sphagnaceae

Like its relatives, this peat-forming moss grows on wet ground, and holds large amounts of water. Each stem ends in a flat-topped rosette of small branches.

24 in
60 cm

COMMON HAIR-CAP MOSS
Polytrichum commune
F: Polytrichaceae

This tall, tussock-forming moss is common in wet moorlands throughout the Northern Hemisphere. Its stems are stiff and unbranched, with narrow, pointed leaves.

½ in
1.5 cm

CORD MOSS
Funaria hygrometrica
F: Funariaceae

One of the world's most widespread mosses, this mat-forming species is particularly common on disturbed ground. When ripe, its spore capsules have conspicuous orange stalks.

FERNS AND RELATIVES

Most ferns can be recognized by their graceful fronds, which unroll as they grow. Together with horsetails and whisk ferns, they make up a diverse and ancient group of nonflowering plants that reproduce by means of spores. Ferns grow in a wide variety of habitats, although the majority thrive where there is moisture and shade.

DIVISION	PTERIDOPHYTA
CLASSES	4
ORDERS	11
FAMILIES	37
SPECIES	12,000

DEBATE

LIVING FOSSILS

Horsetails have changed little in over 300 million years, although most living species are much smaller than the giant forms that existed in prehistoric times. One of the largest genera, called *Calamites*, grew up to 65 ft (20 m) high, and had massive ridged stems over 24 in (60 cm) across. Opinions differ about how horsetails should be classified. Some botanists rank them in a separate division, but there is increasing evidence that they have close links with ferns, and should be classified in the same clade, or evolutionary group.

Some ferns are small and easily overlooked, but the group also includes large treelike species that can be over 50 ft (15 m) high. Many are compact plants, with a single cluster of fronds, but others have creeping stems that sprout fronds as they grow. Bracken—one of the most widespread creeping species—is particularly vigorous. Over many years, it can produce clumps, or clones, over ½ mile (800 m) across. Ferns also include species that live in fresh water and a wide variety of epiphytic species, which live on other plants.

Fern fronds are often finely divided, and usually develop from tightly coiled buds, known as fiddleheads. Ferns form spores on the underside of the fronds, in structures that look like raised dots or lines. In many fern species, all the fronds can produce spores, but in some, the fronds are of two kinds: fertile fronds form spores, while sterile fronds concentrate on collecting sunlight to enable the fern to grow. When a fern spore germinates and starts developing, it produces an intermediate stage known as a gametophyte. Tiny, flat, and paper-thin, this eventually produces a new sporophyte, or spore-forming plant.

FERN RELATIVES

As well as true ferns, this group includes some closely related plants. The most distinctive of these are horsetails—upright plants with a rough texture, and hollow, cylindrical stems. Their stems are symmetrical, with whorls of slender branches attached to equally spaced joints. Horsetails get their texture from granules of silica, and in the past they were widely used for scouring pots and pans.

Whisk ferns and adder's tongues are small but intriguing plants, with twig-shaped stems or a single divided frond. Like true ferns and horsetails, they also reproduce by means of spores.

v CHARACTERISTIC COIL
The delicate tips of young fern fronds are protected inside tight coils. These unwind as they stretch up toward the light.

HORSETAILS

32 in/80 cm

COMMON HORSETAIL
Equisetum arvense
F: Equisetaceae
Widespread in the Northern Hemisphere, this horsetail can be a troublesome weed. Its black underground rhizomes sprout hollow shoots, bearing symmetrical rings of bright green branches.

TRUE FERNS

PILLWORT
Pilularia globulifera
F: Marsileaceae
This marshland fern from western Europe forms clumps resembling tufts of grass. Its spores develop at ground level, in green capsules shaped like pills.

6 in/15 cm

WATER CLOVER
Marsilea quadrifolia
F: Marsileaceae
With its four-lobed fronds, this clump-forming aquatic fern looks deceptively like a flowering plant. It is widely distributed across the Northern Hemisphere.

WHISK FERNS, MOONWORTS, AND ADDER'S TONGUES

24 in/60 cm

WHISK FERN
Psilotum nudum
F: Psilotaceae
A primitive relative of true ferns, this largely tropical plant has leafless brushlike stems, bearing berrylike capsules that produce its spores.

8 in/20 cm

ADDER'S-TONGUE FERN
Ophioglossum vulgatum
F: Ophioglossaceae
This unusual fern has a single oval frond, clasping a slender spore-producing stalk. It grows in grassy places throughout the Northern Hemisphere.

COMMON MOONWORT
Botrychium lunaria
F: Ophioglossaceae
Found worldwide in temperate regions, moonwort has a single frond. Spores are produced from rounded capsules, borne on a branched stalk.

½ in/1.5 cm

MOSQUITO FERN
Azolla filiculoides
F: Azollaceae
A floating plant with mat-forming fronds, mosquito fern spreads rapidly across lakes and ponds. It is widespread in warm parts of the world.

3¼ ft/1 m

STICHERUS CUNNINGHAMII
F: Gleicheniaceae
This distinctive fern from New Zealand has a pencil-thin stem topped by a horizontal crown of narrow, radiating fronds. It spreads by creeping rhizomes.

5 ft/1.5 m

ROYAL FERN
Osmunda regalis
F: Osmundaceae
Often cultivated, this stately fern from the Northern Hemisphere has a rosette of spreading fronds, topped by much narrower fronds that bear its spores.

¾ in/2 cm

FLOATING FERN
Salvinia natans
F: Salviniaceae
Often forming a dense carpet, this water fern has small, oval leaves covered with water-repellent hairs. It is common throughout the tropics.

TASMANIAN TREE FERN
Dicksonia antarctica
F: Dicksoniaceae
This sturdy, stemmed tree fern is widespread in Tasmania and southeast Australia. It needs shady conditions, and usually grows among trees.

33 ft
10 m

SILVER TREE FERN
Cyathea dealbata
F: Cyatheaceae
This tree fern gets its name from its fronds, which have silvery undersides. Native to New Zealand, it grows in open forest and scrub.

60 ft
18 m

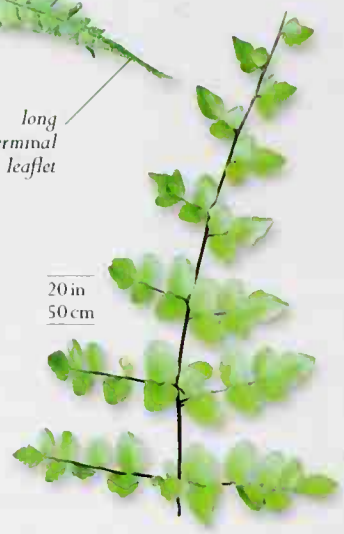
BLACK TREE FERN
Cyathea medullaris
F: Cyatheaceae
From New Zealand, this tall and slender tree fern has a sooty-black trunk and dark leaf stalks, contrasting with its bright green fronds.

25 ft
8 m

SOFT TREE FERN
Cyathea smithii
F: Cyatheaceae
Native to New Zealand and sub-Antarctic islands, this is the most southerly tree fern. It often has a collar of dead fronds hanging beneath its crown.

SILVER BRAKE
Pteris argyraea
F: Pteridaceae
This shade-loving fern is named for its distinctive fronds, which have a silvery white central stripe. A pantropical species, it forms extensive clumps.

PAINTED BRAKE
Pteris tricolor
F: Pteridaceae
From Malaysia, painted brake has an unusual range of colors: its fronds are purple when young, becoming metallic green as they mature.



CLIFF BRAKE
Pellaea viridis
F: Pteridaceae
Native to South Africa, this drought-resistant fern has shining green fronds with wiry black stems. It grows in open woodlands on mountains.

BLACK MAIDENHAIR FERN
Adiantum capillus-veneris
F: Adiantaceae
Found in crevices on limestone, this widespread fern has bright green, translucent leaflets that contrast with its slender black stems.

SILVER LIP FERN
Cheilanthes argentea
F: Adiantaceae
From eastern Asia, this small, evergreen fern has wedge-shaped fronds with black veins and distinctive silvery markings on their undersides.

NORTHERN BEECH FERN
Thelypteris phegopteris
F: Thelypteridaceae
Found as far north as Greenland, this compact fern grows in a variety of habitats from woodlands to rocky tundra.

MOUNTAIN FERN
Oreopteris limbosperma
F: Thelypteridaceae
Found in damp habitats in acidic soil, this clump-forming European fern gives off a lemony smell if its fronds are bruised.

LADDER BRAKE
Pteris vittata
F: Pteridaceae
Widespread in warm regions, this fern has upright or arching fronds with narrow linear leaflets. It usually grows on limestone and in alkaline soil.

BRACKEN FERN
Pteridium aquilinum
F: Dennstaedtiaceae
Found on every continent except Antarctica, bracken fern spreads vigorously by growing underground rhizomes. It often dies back in winter, sprouting new fronds in spring.

SQUIRREL'S-FOOT FERN
Davallia trichomanoides
F: Davalliaceae
This epiphytic fern from Malaysia creeps over trees and other plants. Its rhizomes have furlike scales and tips that resemble a squirrel's feet.

EUROPEAN CHAIN FERN
Woodwardia radicans
F: Blechnaceae
A luxuriant fern from damp, shaded habitats, this European species has large arching fronds that sometimes produce bulbils (small bulbs) at their tips.

DEER FERN
Blechnum spicant
F: Blechnaceae
This evergreen fern has spreading sterile fronds, and upright fertile fronds with leaflets like narrow ribs. It is native to the temperate Northern Hemisphere.

winged midrib

toothed, pale green leaflets

24 in
60 cm

SENSITIVE FERN
Onoclea sensibilis
F: Woodsiaceae

Originally from North America and eastern Asia, this wetland fern has sterile fronds that die down soon after the first frost.

16 in
40 cm

OAK FERN
Gymnocarpium dryopteris
F: Woodsiaceae

Delicate bright green fronds, sprouting separately, distinguish this northern fern. It grows in shaded screes as well as in woodlands.

MALE FERN
Dryopteris filix-mas
F: Dryopteridaceae

One of the most common woodland ferns in Europe, this species has a crown of concentric fronds shaped like the tail of a shuttlecock.

4 ft
1.2 m

spore capsules on underside of fronds

4 ft
1.2 m

SOFT SHIELD FERN
Polystichum setiferum
F: Dryopteridaceae

Native to damp European woodlands, soft shield fern has feather-shaped fronds, with leaflets turned at an angle, instead of lying flat.

16 in
40 cm

BRITTLE BLADDER-FERN
Cystopteris fragilis
F: Woodsiaceae

Named for its rounded spore capsules borne on the underside of its fronds, this fern grows in temperate regions worldwide.

fronds form cone-shaped crown

5 ft
1.5 m

OSTRICH FERN
Matteuccia struthiopteris
F: Woodsiaceae

Native to the Northern Hemisphere, this tall waterside fern has a symmetrical crown of sterile fronds in summer, followed by brown fertile fronds in the winter.

24 in
60 cm

HART'S-TONGUE FERN
Asplenium scolopendrium
F: Aspleniaceae

With its glossy strap-shaped fronds, this fern is often cultivated as an ornamental plant. It grows wild in Europe, western Asia, and North America.

6 in
15 cm

WALL RUE
Asplenium ruta-muraria
F: Aspleniaceae

Widespread across the Northern Hemisphere, this small tuft-forming fern grows on limestone rocks and on walls containing lime-rich mortar.

12 in
30 cm

COMMON POLYPODY
Polypodium vulgare
F: Polypodiaceae

Instead of forming clumps, this fern sprouts separate fronds along its creeping rhizome. It is common on rocks, trees, and leaf litter in northern temperate regions.

8 in
20 cm

MAIDENHAIR SPLEENWORT
Asplenium trichomanes
F: Aspleniaceae

Occurring from the tropics to sub-Arctic regions, this small clump-forming fern grows in rocky places. Its fronds have paired elliptical leaflets.

COMMON STAGHORN FERN
Platycerium bifurcatum
F: Polypodiaceae

Found in Indonesia and Australasia, this impressive epiphyte grows on tree trunks. It has kidney-shaped, sterile fronds and spreading fertile fronds shaped like antlers.

35 in/90 cm

CYCADS, GINKGOS, AND GNETOPHYTES

Found mainly in warm parts of the world, the cycads, ginkgos, and gnetophytes are three ancient divisions of nonflowering plants with strikingly varied shapes. They range from climbers and low-growing shrubs to plants that are easily mistaken for palms.

DIVISION	CYCADOPHYTA
CLASS	1
ORDER	1
FAMILIES	3
SPECIES	304

DIVISION	GINKGOPHYTA
CLASS	1
ORDER	1
FAMILY	1
SPECIES	1

DIVISION	GNETOPHYTA
CLASS	1
ORDERS	3
FAMILIES	3
SPECIES	70

These three groups are traditionally classed, along with conifers, as gymnosperms—a word that means "naked seed." Unlike flowering plants, gymnosperms form their seeds on exposed surfaces, which are typically specialized scales. Flowering plants produce their seeds in closed chambers, or ovaries.

Scientists have not yet resolved the exact relationship between cycads, ginkgos, and gnetophytes. Nor can they say where they stand in relation to conifers and flowering plants. At the cellular level, some features of gnetophytes suggest they are more closely related to conifers than to cycads and ginkgos, but they also have features in common with flowering plants.

Apart from the nature of their seeds, the three groups have little in common, and hardly ever grow in the same place. Cycads grow mainly in the tropics and subtropics, while the single surviving species of ginkgo comes from China. Gnetophytes are more diverse, including trees and climbers from the tropics, densely branched shrubs from dry habitats, and the bizarre *Welwitschia*, which grows only in the Namib Desert of southwest Africa.

VARYING FORTUNES

Cycads have a long history, dating back nearly 300 million years. Once an important part of the world's vegetation, they have gradually lost ground in the face of competition from flowering plants. Today, nearly a quarter of cycad species are endangered, under threat from illegal plant collection and habitat change.

Gnetophytes face fewer problems, and the ginkgo has seen a dramatic improvement in its status. For centuries it was preserved by Buddhist monks, who grew it in temple gardens long after it had vanished in the wild. Introduced to Europe in the 1700s, it proved easy to grow and highly tolerant of polluted air. It is now planted worldwide in parks and on city streets.

∨ BUILT TO LAST
Like palms, cycads usually have a single crown of compound leaves, surrounding a central growing point, or apical meristem. Their tough leaves are able to withstand strong sunshine and drying winds.

CYCADS

JAPANESE SAGO PALM
Cycas revoluta
F: Cycadaceae

Unrelated to true sago, this palmlike cycad from southern Japan has a thick stem and glossy leaves. It is widely cultivated as an ornamental plant.

EASTERN CAPE BLUE CYCAD
Encephalartos horridus
F: Zamiaceae

Unlike most cycads, this low-growing semidesert species from South Africa has gray-blue leaves, composed of stiff leaflets armed with sharp spines.

4½ft/1.4m

PRICKLY CYCAD
Encephalartos altensteinii
F: Zamiaceae

Found near South Africa's eastern coast, this tall, subtropical cycad is named for its spiny leaves. Its yellow cones produce bright red seeds.

MEXICAN FERN PALM
Dioon edule
F: Zamiaceae

A cycad rather than a true palm, this slow-growing plant from eastern Mexico has oval seed cones up to 12 in (30 cm) long.

MEXICAN HORNCONE
Ceratozamia mexicana
F: Zamiaceae

This robust cycad from eastern Mexico has a large crown of spreading leaves and gray-green cones with distinctive horns on their scales.

COONTIE
Zamia pumila
F: Zamiaceae

Once used as a source of starch, this dwarf cycad from the Caribbean has short, half-buried stems and upright, reddish brown cones.

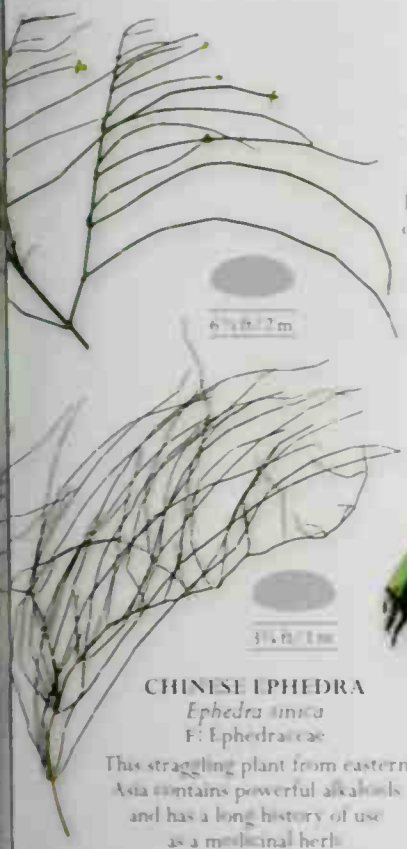
MACROZAMIA MOOREI
F: Zamiaceae

One of Australia's tallest cycads, this palmlike plant has giant seed cones up to 36 in (990 cm) long. It grows in dry woodlands.

BURRAWONG
Macrozamia communis
F: Zamiaceae

Native to Australia's southeast coast, this cycad has large cones with red, fleshy seeds. It often grows in dense stands.

GNETOPHYTES



LONGLEAF JOINT-FIR
Ephedra trifurca
F: Ephedraceae

Also known as Mexican tea, this mound-forming plant has a dense mass of leafless stems. It grows in deserts in Mexico and the southern United States.

CHINESE EPHEDRA
Ephedra sinica
F: Ephedraceae

This straggling plant from eastern Asia contains powerful alkaloids and has a long history of use as a medicinal herb.

MELINJO
Gnetum gnemon
F: Gnetaceae

A nonflowering tree from southeast Asia and the Pacific, melinjo has evergreen leaves and nutlike seeds. Both are used in cooking.

WELWITSCHIA
Welwitschia mirabilis
F: Welwitschiaceae

Endemic to the Namib Desert, this extremely long-lived plant has a single pair of strap-shaped leaves. Over the centuries they crack and split, creating a tangled mound of foliage.

GINKGO

MAIDENHAIR TREE
Ginkgo biloba
F: Ginkgoaceae

This distinctive tree is easily recognized by its fan-shaped leaves, which turn bright yellow in fall. Originally restricted to southern China, it is now cultivated worldwide.

CONIFERS

Conifers evolved over 300 million years ago, long before the world's first broad-leaved trees. With their tough, waxy leaves, conifers thrive in harsh climates. They are less diverse than broad-leaved trees, but they dominate forests on cold mountains, and in the far north.

DIVISION	PINOPHYTA
CLASS	1
ORDER	1
FAMILIES	7
SPECIES	630

Between areas of open tundra, conifers grow far to the north of the Arctic Circle, forming the largest forest on Earth.

Although relatively few in species, conifers include the world's tallest trees, as well as the heaviest, the longest-lived, and some of the most widespread. Conifers are traditionally placed in a group known as gymnosperms, along with cycads, ginkgos, and gnetophytes. Unlike broad-leaved trees, they do not have flowers and produce pollen and seeds in cones.

LEAVES AND CONES

Most conifers are evergreen, with highly resinous leaves that are good at withstanding cold winds and strong sunshine. Pines have slender needles, arranged singly or in bundles, while other conifers often have linear leaves or flat scales. A few conifers—including larches and some redwoods—are deciduous, with soft leaves that are shed each year.

Conifers have two types of cones, which normally grow on the same tree. Male cones produce pollen. Small, soft, and often very numerous, they typically appear in spring, and wither soon after shedding their pollen into the air. The larger female cones contain one or more seeds. They can take several years to develop, and usually become hard and woody when mature.

The cones of some species, including firs and cedars, release their seeds by slowly disintegrating on the tree. Pine cones remain intact, and often remain on the tree long after they are ripe. Most of them shed their seeds in dry weather, when their scales open wide, but some hold on to their seeds until they are scorched. This is a specialized adaptation that allows pines to recolonize areas that have been burned by forest fires.

A few groups of conifers, the yews, junipers, and podocarps, have small berrylike cones with fleshy scales. Their seeds are spread by birds, which scatter them as they feed.

v CONIFERS IN CONTROL
Conifers often form extensive single-species stands. These pines are growing in California's Yosemite National Park in the USA.

115 ft
35 m

CONE

FOUR-SIDED RIGID LEAVES

COLORADO BLUE SPRUCE
Picea pungens
F: Pinaceae

Bright blue-gray leaves, with prickly tips, make this a popular ornamental tree. Native to western North America, it typically grows on mountains.

165 ft/50 m

GRAND FIR
Abies grandis
F: Pinaceae

The grand fir is a tall, fast-growing tree that is native to western North America. Its leaves have an orangelike scent when crushed.

130 ft/40 m

CALIFORNIA RED FIR
Abies magnifica
F: Pinaceae

This drought-resistant fir is found on dry mountain slopes. It has leaves that curve upward and upright cones up to 8 in (20 cm) long.

130 ft/40 m

EUROPEAN SILVER FIR
Abies alba
F: Pinaceae

Named after the silver bands on the underside of its leaves, this fir has upright resinous cones. They disintegrate in order to scatter their seeds.

165 ft/50 m

CAUCASIAN FIR
Abies nordmanniana
F: Pinaceae

Widely grown as a Christmas tree, this fir is Europe's tallest conifer. It originally comes from mountains in the Black Sea region.

SITKA SPRUCE
Picea sitchensis
F: Pinaceae

Thriving in cold, wet conditions, the sitka spruce is often grown as a forestry tree. It comes from the coastal belt of western North America.

undersides of leaves have white bands

165 ft/50 m

cylindrical cones with toothed scales

165 ft
50 m

NORWAY SPRUCE
Picea abies
F: Pinaceae

An important lumber tree, this fast-growing conifer has spiky leaves and cylindrical cones. Its natural range includes most of northern Europe.

115 ft
35 m

SCOTCH PINE
Pinus sylvestris
F: Pinaceae

Ranging from the British Isles to China, the Scotch pine is the world's most widespread conifer. When mature, it has peeling bark and often an asymmetrical shape.

LONG, THICK LEAVES

65 ft/20 m

CONE WITH EDIBLE SEEDS

STONE PINE
Pinus pinea
F: Pinaceae

Prized for its edible seeds (pine nuts), this Mediterranean pine has large oval cones, and an elegant umbrella-shaped outline when mature.

50 ft/15 m

SINGLE-LEAF PINYON
Pinus monophylla
F: Pinaceae

Unique among pines, this low-growing tree has leaves that grow singly, rather than in clusters. It comes from rocky slopes in Mexico and the American Southwest.

33 ft
10 m

LODGEPOLE PINE
Pinus contorta
F: Pinaceae

Growing in coastal dunes and bogs, this North American pine has paired leaves and prickly cones. The cones release their seeds after being scorched by fire.

100 ft
30 m

male pollen producing cones

stiff, sharp needles

65 ft/20 m

AROLLA PINE
Pinus cembra
F: Pinaceae

Found on European mountains, this slow-growing tree produces small cones that fall intact, like those of other pines. Its seeds are then dispersed by birds.

115 ft/35 m

MARITIME PINE
Pinus pinaster
F: Pinaceae

Native to the western Mediterranean, the maritime pine grows rapidly on poor, sandy soil. It has glossy brown cones that are up to 8 in (20 cm) long.

130 ft
40 m

AUSTRIAN PINE
Pinus nigra
F: Pinaceae

Tall, rangy, and open-crowned, this pine has long leaves arranged in pairs. Despite its name, it is widespread throughout Europe, typically growing on limestone.

80 ft/25 m

CHINESE PINE
Pinus tabuliformis
F: Pinaceae

With age, this oriental pine develops a distinctive flat, spreading crown. It grows on mountains, and produces small egg-shaped cones.

MONTEREY PINE
Pinus radiata
F: Pinaceae

Originally restricted to a small area of California, this fast-growing pine is now widely planted for lumber, particularly in the Southern Hemisphere.

»

male cones wither after shedding pollen

165 ft/50 m

DEODAR
Cedrus deodara
F: Pinaceae

Native to the western Himalayas, this fast-growing cedar has branches that droop at their tips. Its cones are purple-brown when ripe.

immature cones

200 ft/60 m

DOUGLAS FIR
Pseudotsuga menziesii
F: Pinaceae

One of the world's tallest conifers, the Douglas fir grows in western North America. Its cones have projecting bracts formed from modified scales.

mature cone with three-pronged bracts

130 ft
40 m

200 ft
60 m

WESTERN HEMLOCK
Tsuga heterophylla
F: Pinaceae

From western North America, this is the largest hemlock. It thrives in cool, damp conditions, and can live to be over 1,000 years old.

130 ft
40 m

GOLDEN LARCH
Pseudolarix amabilis
F: Pinaceae

Native to eastern China, the golden larch turns brilliant yellow in fall before losing its leaves. Its cones break up as they scatter their seeds.

130 ft/40 m

30 ft/9 m

130 ft
40 m

ATLAS CEDAR
Cedrus atlantica
F: Pinaceae

This North African cedar has short, needlelike leaves and upright, barrel-shaped cones. When ripe, the cones slowly break up to release their seeds.

CEDAR OF LEBANON
Cedrus libani
F: Pinaceae

A majestic conifer with spreading branches, the cedar of Lebanon is now rare in the wild, but is widely planted as an ornamental tree.

100 ft/30 m

JAPANESE LARCH
Pseudolarix kaempferi
F: Pinaceae

A deciduous tree—like all larches—this has soft leaves and persistent woody cones with downcurved scales. It grows on mountains in northern Japan.

165 ft/50 m

MONKEY PUZZLE
Araucaria araucana
F: Araucariaceae

Originally from the mountains of Chile, this primeval-looking tree has spirally arranged, sharply pointed leaves. Mature trees develop an umbrella-like crown.

CHINESE PLUM-YEW
Cephalotaxus fortunei
F: Cephalotaxaceae

This small, densely branched conifer has fleshy fruits, which turn purple-brown when ripe. It grows in mountain forests in central and eastern China.

JAPANESE UMBRELLA PINE
Sciadopitys verticillata
F: Cupressaceae

As a wild tree, this pinelike conifer is restricted to the mountains of Japan. It has slender leaves arranged like the spokes of an umbrella.

LAWSON CYPRESS
Chamaecyparis lawsoniana
F: Cupressaceae

Like other cypresses, this has small cones and sprays of tiny scalelike leaves. Originally from western North America, it exists in many cultivated forms.

JAPANESE CEDAR
Cryptomeria japonica
F: Cupressaceae

A cypress rather than a true cedar, this tree has slender leaves and small rounded cones. It grows on mountains in China and Japan.

WESTERN JUNIPER
Juniperus occidentalis
F: Cupressaceae

This long-lived tree grows on rocky mountain slopes in the western United States. Like other junipers, it produces seeds inside berrylike cones.

CHINESE JUNIPER
Juniperus chinensis
F: Cupressaceae

Widespread in temperate eastern Asia, this shrub or small tree has prickly leaves when young, and scalelike leaves when mature.

COAST REDWOOD
Sequoia sempervirens
F: Cupressaceae

Native to the coast of northern California, this is the world's tallest tree. Mature trees have soaring trunks and relatively sparse branches, and can be over 1,000 years old.

GIANT SEQUOIA
Sequoiadendron giganteum
F: Cupressaceae

This California redwood is the world's most massive tree. The largest living specimens weigh over 5,000 tons, and have fireproof bark up to 2 ft (60 cm) thick.

DAWN REDWOOD
Metasequoia glyptostroboides
F: Cupressaceae

Native to central China, this deciduous redwood is extremely rare in the wild. Until the 1940s it was thought to be extinct, being known only from fossils.

MONTEREY CYPRESS
Cupressus macrocarpa
F: Cupressaceae

Although widely cultivated, the wild Monterey cypress is restricted to a small region of California's coast. Mature trees typically have an irregular spreading shape.

TAIWANIA
Taiwania cryptomerioides
F: Cupressaceae

One of Asia's largest conifers, this tropical species has a trunk up to 10 ft (3 m) thick. It has spine-tipped leaves and small, rounded cones.

SWAMP CYPRESS
Taxodium distichum
F: Cupressaceae

Also known as the bald cypress, this deciduous conifer grows in swamps in the southeastern United States. Its trunk often has a buttressed base.

WESTERN RED CEDAR
Thuja plicata
F: Cupressaceae

This large tree grows in northwestern North America. It has flat sprays of small scalelike leaves, and its wood is highly rot-resistant, even when dead.

CALIFORNIA NUTMEG
Torreya californica
F: Taxaceae

This rare conifer is restricted to canyons and mountains in California. It is unrelated to the true nutmeg, although it has nutlike seeds.

EUROPEAN YEW
Taxus baccata
F: Taxaceae

This long-lived tree produces seeds in fleshy arils—modified cone scales. Found wild in Europe and southwest Asia, it is commonly planted.

FLOWERING PLANTS

With over 250,000 species, flowering plants—or angiosperms—are by far the largest group of plants, as well as the most diverse. They play a vital role in most land-based ecosystems, producing food and shelter for animals and many other living things.

DIVISION	ANGIOSPERMAE
CLADES	3
ORDERS	40
FAMILIES	603
SPECIES	About 255,000

Wind-pollinated flowers such as hazel catkins shed clouds of pollen grains into the air. They are rarely brightly colored.

Animal-pollinated flowers are usually conspicuous, and have sticky pollen grains. Hummingbirds transfer pollen as they feed.

Fleshy fruits evolved to attract animals. Wild cucumbers are eaten by antelopes, which scatter the seeds in their droppings.

Dry fruits often burst open when their seeds are ripe. This willowherb is scattering its fluffy seeds into the wind.

The first flowering plants evolved 140 million years ago, which makes them relative latecomers to life on Earth. Since then, they have become the dominant forms of plant life. The smallest flowering plants are not much bigger than a pinhead, but this group also includes all broadleaved trees, and a variety of other species, from cacti and grasses to orchids and palms.

Flowering plants share several key features that help make them successful. Foremost among these are flowers—actually a collection of highly modified leaves. In most flowers, the outermost layers are the sepals, then the petals. These surround the male stamens, which make pollen, and the female carpels, which collect pollen arriving from similar flowers, so that their female ovules can develop into seeds. Some flowers spread their pollen through the air, but many more use animals to transfer their pollen. In these showy species, flowers lure animals to sip the sugary nectar in the innermost part of the flower, brushing past the pollen on the way. These plants mostly attract insects, but birds and bats are also important pollinators.

STRATEGIES FOR SPREADING

Flowering plants are not unique in making seeds, but they are the only plants that produce them in fruits. A fruit develops from a flower's ovaries—the closed chambers that house the seeds, close to the flower's central stem. Fruits have a double function: to protect the seeds and to help them spread. Fleshy fruits do this by attracting animals, which feed and scatter the seeds in their excrement. Dry fruits work in a variety of ways. Some burst open when their seeds are ripe. Others have hooks that latch onto clothing, skin, or fur. Still more drift in water or through the air. Many flowering plants spread by the way they grow, often producing new plants from creeping stems. This can create vast, interconnected clones. The largest examples, formed by North American aspen trees, stretch over 100 acres (40 ha), and may be 10,000 years old.

ATTRACTING ATTENTION >
Unlike most flowers, this hellebore has colorful sepals, and small green petals on the inside. It is pollinated by bees.

FLOWERING PLANTS GROUPS

Angiosperm classification is in flux as DNA sequencing is revolutionizing our understanding of relationships between species. The groupings below reflect the latest thinking.

BASAL FAMILIES

» 124

MAGNOLIIDS

» 126

MONOCOTYLEDONS

» 130

EUDICOTYLEDONS

» 150

BASAL ANGIOSPERMS

Of the more than 50 orders of flowering plants, or angiosperms, a few, known as basal angiosperms, evolved early and still exist today.

Outwardly, basal, or primitive, angiosperms have little in common, and grow in widely scattered parts of the world. They include trees, shrubs, and climbers, as well as submerged and emergent water plants. Some have large, eye-catching flowers, while in others the flowers are small or insignificant. Most are pollinated by insects, although hornworts bloom underwater and produce drifting pollen grains.

Fossil and genetic evidence shows that basal angiosperms evolved at different times. The very first angiosperms appeared about 140 million years ago. These were probably the Amborellales, an order that exists in the form of a single species of shrub, found on only one island in the South Pacific. Later, the Nymphaeales appeared. Aquatic plants with showy flowers, they include more than 70 species of water lilies, found all over the globe. Two other orders then followed: the Austrobaileyales, with nearly 100 species of woody plants—perennials with a hard durable stem made of wood—found mainly in the tropics; and the Chloranthales, a small order of about 60 species, from the tropical Americas, eastern Asia, and the Pacific. The Ceratophyllales, or hornworts, may have been the last to split off. Meanwhile, the main line of flowering plants underwent a massive radiation, or diversification, leading to the vast majority of species alive today.

DIVISION	ANGIOSPERMAE
GROUPS	BASAL ANGIOSPERMS
ORDERS	5
FAMILIES	9
SPECIES	251

DEBATE

MYSTERIOUS ORIGINS

Angiosperms evolved from nonflowering seed plants, but exactly which ones is not yet known. Various kinds have been suggested: seed ferns, a group that died out over 50 million years ago; or more probably gnetophytes, a group of mostly woody evergreen plants from warm regions, which although few in number, still survive.

CHLORANTHALES

There are four genera in the family Chloranthaceae, which is the sole family in the order Chloranthales. Members of this primitive order are aromatic trees and shrubs with pairs of toothed leaves and inconspicuous flowers that have no petals.

24 in/60 cm

SARCANDRA GLABRA
F: Chloranthaceae

With a range of medicinal uses, this evergreen inhabits damp ground, especially wooded streambanks, in southeast Asia, China, and Japan.

CERATOPHYLLALES

An order of submerged freshwater plants, Ceratophyllales is not closely related to any other order. Its members belong to a single family, Ceratophyllaceae, and are characterized by dissected whorled leaves, spiny one-seeded fruits, separate male and female flowers, and a lack of roots.

3¼ ft
1 m

RIGID HORNWORT
Ceratophyllum demersum
F: Ceratophyllaceae

This is a submerged species with no roots, inhabiting ponds and ditches in non-arctic Europe. It has tiny flowers and whorls of leaves.

6½ ft
2 m

AMBORELLALES

This order of primitive evergreen shrub contains a single family, which has a single genus with only one species, *Amborella trichopoda*. It bears small flowers, males and females being produced on separate plants, and red berries, each containing a single seed.

AMBORELLA TRICHOPODA
F: Amborellaceae

Found only in rain forests on the island of New Caledonia in the South Pacific, this is a primitive flowering plant, threatened by habitat destruction.

AUSTROBAILEYALES

The order Austrobaileyales is made up of only four families. Members of this order are trees, shrubs, and climbers. The flowers of most species are single and have many corolla petals. Perhaps the best known species is star anise, a fragrant spice.

50 ft/15 m

60 ft/18 m

STAR ANISE
Illicium verum
F: Illiciaceae

Widely used for flavoring, star anise fruits are woody and star-shaped. This woodland species is native to China and Vietnam.

AUSTROBAILEYA SCANDENS
F: Austrobaileyaceae

The flowers of this rare primitive climber, found only in rain forests in Queensland, Australia, smell like rotting fish to attract pollinating flies.

NYMPHAEALES

This is a primitive order of aquatic plants, with floating, submerged, or, more rarely, emergent leaves. The order Nymphaeales are the water lilies, which often grown ornamentally for their showy flowers. Nymphaeales are cultivated throughout the world.

WATER LILY FLOWER

10ft/3m

RIMMED LEAVES

AMAZON WATER LILY
Victoria amazonica
F: Nymphaeaceae
Native to deep Amazonian backwaters, this water lily has enormous round leaves with upright rims. The flowers open at night.

star-shaped semidouble flower

6½ft/2m

NYMPHAEA 'SUNRISE'
F: Nymphaeaceae
With large, showy, fragrant flowers and mid-green floating foliage, this hybrid, thought to be of American origin, is one of the largest flowering water lilies.

FANWORT
Cabomba caroliniana
F: Cabombaceae
From still, freshwater habitats in the central and southeastern United States, fanwort has submerged and floating leaves. It can be invasive.

20in/50cm

WHITE WATER LILY
Nymphaea alba
F: Nymphaeaceae
This European species has fragrant flowers and its fruits ripen under water, releasing floating seeds. It inhabits lakes, ponds, and slow-flowing rivers.

5ft/1.5m

starlike, pure white flowers

CHINESE FOXNUT
Euryale ferox
F: Nymphaeaceae
This inhabitant of deep, slow-flowing water and still water in parts of Asia has prickly leaves, flowers, and one-seeded berries.

5ft/1.5m

sharp prickles protect leaves above surface from animals

stems, seeds, and fruits are all edible

bright purple flower

green-green to olive-green leaves

v FLOATING FLOWERS
Water lily flowers are hermaphrodite—they have both male and female organs. However, they do not normally pollinate themselves, as the female reproductive parts mature before the male ones start producing pollen. This time lag increases the chances that the flower is fertilized by incoming pollen, rather than by pollen that the flower makes itself.

v LEAVES
The water lily has large leaves, up to 12 in (30 cm) across. Unlike most leaves, their stomata (breathing pores) are on the upper surface, which has a water-repellent coating.

^ FLOWER
The flowers have numerous white petals and bright yellow stamens, and can grow to 6 in (15 cm) in diameter.

^ STEM SECTION
Stems have longitudinal air spaces (aerenchyma), as well as structural tissue, creating buoyancy and allowing oxygen to circulate.

< OVARY SECTION
The female reproductive organs (consisting of ovules, ovary, and stigma) are fused together. Cavities contain ovules, which turn into seeds when fertilized.

WHITE WATER LILY
Nymphaea alba

One of about 50 wild species of water lilies, this handsome plant lives in still or slow-flowing water, casting a deep shade with its rounded, glossy leaves. It grows in water up to 5 ft (1.5 m) deep, and flowers in mid- to late summer, producing a succession of pure white blooms. Each flower lasts for three to four days, opening in the morning and closing by late afternoon. They attract pollinating beetles, which often spend the night inside the flowers before being released at dawn. White water lilies are useful to water animals: pond snails glue their eggs to the underside of the leaves, and fishes hide beneath them, avoiding predatory birds. After the flowers are pollinated, they produce buoyant seeds. These float for several weeks, before sinking into the mud.

SIZE Leaf diameter 4–12 in (10–30 cm)
HABITAT Ponds, streams, lakes
DISTRIBUTION Europe
LEAF TYPE Simple, orbicular with a basal notch

flower bud enclosed in protective sepals

flower supported by long, thick stalk

large floating leaf maximizes the surface area, in order to capture sunlight for photosynthesis

fibrous root

buoyant stem (or petiole) enables the leaf to reach the top of the pond

folded petal

stamen (male part that produces and releases pollen)

sepal

inner petal

stigma (female part that collects pollen)

ovary (containing ovules which, when fertilized, become seeds)

< ROOT SYSTEM
The small, fibrous root system is embedded in the mud. Its primary purpose is to soak up water and absorb oxygen, while also helping anchor the plant.

< INSIDE THE BUD
This cross section shows the reproductive organs of the water lily. Each long, pointed bud has four to five pale green sepals that enclose the flower.

MAGNOLIIDS

The magnoliids are a large group of primitive flowering plants that are botanically between basal angiosperms and monocots.

Found in tropical and temperate regions, the magnoliids form a major plant group, that evolved early in the history of flowering plants. They take their name from the magnolia family, which is one of the largest in the group. Plants in this family nearly all have woody stems, and some kinds grow into large trees. However, the group also includes herbaceous or nonwoody species, both as freestanding plants and as climbers.

Some herbaceous magnoliids have highly specialized flowers. In birthworts and pipevines, for example, the flower is shaped like a flaring tube, lined with backward-pointing hairs. Flowers like these act as temporary traps for pollinating flies, which are attracted by a powerful scent. But these are an exception. Most magnoliid flowers are structurally simple, with numerous spirally arranged parts, attached separately to a central stem. Instead of sepals and petals (see p.122) the flowers have a single layer of flaps that are similar in color, size known as tepals. The fossil record shows that similar flowers existed more than 100 million years ago.

COMMON CHARACTERISTICS

Magnoliids are grouped together mainly by genetic evidence, but they also share features that can be seen with a microscope, or with the naked eye. At a microscopic level, their pollen grains have a single pore. This small but significant feature links them with monocots, but distinguishes them from eudicots—by far the largest group of flowering plants—which have three-pored pollen grains.

Most magnoliids have leaves with smooth margins, and a network of branching veins. Their fruits may be soft and fleshy, or hard and conelike, and can contain one or several seeds. Species with fleshy fruits use animals to disperse their seeds: many of them are swallowed whole and then scattered by birds. In prehistoric times, wild avocados may have been dispersed by giant ground sloths. Now that ground sloths are extinct, avocados depend on human cultivation to disperse their seeds and ensure survival.

DIVISION	ANGIOSPERMAE
CLADI	MAGNOLIIDAE
ORDERS	4
FAMILIES	20
SPECIES	7,100

DEBATE

PIONEERING PLANTS

Scientists have differing opinions about the growth habit, or shape and lifestyles, of the first flowering plants. According to the "woody hypothesis," these plants were trees or shrubs, like many magnoliids are today. However, a rival view—known as the "paleoherb hypothesis"—suggests that the first angiosperms were herbaceous, or nonwoody, plants with relatively fast life cycles. This meant that they were good at colonizing disturbed ground such as riverbanks. Currently, neither view has proved decisive, although molecular analysis does favor the idea that they were woody plants.

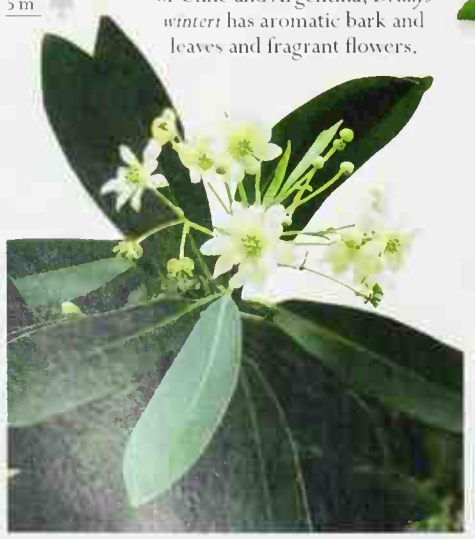
CANELLALES

There are two families in the order Canellales: the Canellaceae and the Winteraceae. These are aromatic trees and shrubs with leathery entire leaves. The flowers in most species have both male and female parts and the fruit is a berry. The leaves and bark of some species can be used medicinally. The Winteraceae are a primitive family—its members have woody stems that contain no water-conducting vessels.

WINTER'S BARK
Drimys winteri
F: Winteraceae

Native to the coastal rain forest of Chile and Argentina, *Drimys winteri* has aromatic bark and leaves and fragrant flowers.

16 ft
5 m



PIPERALES

The order Piperales includes herbaceous plants, climbers, trees, and shrubs and is widely distributed in tropical regions. The stems have scattered bundles of vascular tissue, a characteristic of monocots. Members of the family Piperaceae have tiny flowers that lack petals and are clustered in spikes. Many species are aromatic.

3¼ ft
1 m

BIRTHWORT
Aristolochia clematitis
F: Aristolochiaceae

A foul-smelling and poisonous perennial, birthwort was grown for medicinal use. It is native to Europe, growing in damp places.

4 in
10 cm

ASARABACCA
Asarum europaeum
F: Aristolochiaceae

This European woodland creeper is also called wild ginger. Its glossy evergreen leaves hide insignificant flowers.

13 ft
4 m

fruits, or peppercorns, used dried

BLACK PEPPER
Piper nigrum
F: Piperaceae

An evergreen climber from shady habitats in India and Sri Lanka, this species is widely cultivated for its aromatic fruit.

MAGNOLIALES

Consisting almost exclusively of trees and shrubs, the Magnoliales are a primitive order, widely distributed in the fossil record. Although very variable, most have simple alternately arranged leaves and flowers with both male and female parts. There are six families in the order, of which the Magnoliaceae are the best known, being widely grown in gardens for their spectacular flowers.

tepals protect stamen

65 ft
20 m

100 ft
30 m

TULIP TREE
Liriodendron tulipifera
F: Magnoliaceae

A native of eastern North America, the tulip tree grows in woodlands. The leaves turn yellow before dropping in fall.

MAGNOLIA
Magnolia campbellii
F: Magnoliaceae

The flowers of this deciduous species appear in early spring, before the leaves. Magnolia grows in mountain forests in China, India, and Nepal.

LAURALES

The order Laurales consists of seven families of trees, shrubs, and woody climbing plants. A few genera grow in temperate parts of the world, but most are found in tropical and subtropical regions. Their classification is based on genetic analysis rather than morphological characteristics. Many plants are aromatic and are used in perfumery, cooking, and medicine. Others provide lumber or are grown ornamentally.

BAY LAUREL
Laurus nobilis
F: Lauraceae

The aromatic leaves of this species are used for flavoring. It grows in woods, scrub, and rocky habitats around the Mediterranean.

50 ft/15 m

SASSAFRAS
Sassafras albidum
F: Lauraceae

This suckering deciduous tree of woodlands in eastern North America has aromatic leaves that are brightly colored in fall.

80 ft
25 m

CAROLINA ALLSPICE
Calycanthus floridus
F: Calycanthaceae

Native to woods and streamsides in the southeastern United States, Carolina allspice has aromatic leaves and bark and large, fragrant flowers.

8 ft/2.5 m

LEAF CLUSTER

EDIBLE FRUIT

60 ft
18 m

AVOCADO TREE
Persea americana
F: Lauraceae

Probably originating in southern Mexico, in well-drained parts of rain forests, the avocado tree is widely cultivated, for its edible pear-shaped fruit.

FRUIT

60 ft
18 m

LEAVES

CINNAMON
Cinnamomum verum
F: Lauraceae

The spice cinnamon comes from the aromatic bark of this species, found in lowland forests in Sri Lanka.

CINNAMON STICK

60 ft
18 m

CALIFORNIA LAUREL
Umbellularia californica
F: Lauraceae

Sometimes called "headache tree," as scent from the crushed leaves can cause headaches, this species from the United States flowers in winter.

white to dark pink flowers open early in spring

SCENTED FLOWERS

EVERGREEN LEAVES

65 ft
20 m

YLANG-YLANG
Cananga odorata
F: Annonaceae

Oil from the fragrant flowers of ylang-ylang are used in perfumery. This evergreen tree comes from parts of Asia and Australia.

26 ft
8 m

SWEETSOP
Annona squamosa
F: Annonaceae

Believed to have Caribbean origins, sweetsop, or sugar or custard apple, is widely cultivated. The fruit has edible flesh, which looks and tastes like custard.

GLOSSY LEAVES

mace

SEED, OR NUTMEG, WITH MACE COVERING

60 ft
18 m

NUTMEG
Myristica fragrans
F: Myristicaceae

The spices nutmeg and mace both come from the seeds of *Myristica fragrans*, a native of the Molucca — or Spice — Islands of Indonesia.

26 ft
8 m

LEAVES

EDIBLE FRUIT

PAWPAW
Asimina triloba
F: Annonaceae

This deciduous tree grows in damp woods in the eastern United States. Singly borne flowers produce edible fruit.

MONOCOTYLEDONS

Defined by their unique internal anatomy, monocots include grasses and palms, plus lilies, orchids, and many other ornamental plants.

Early in the evolution of flowering plants, their family tree developed two major branches. A smaller but still substantial branch became the monocotyledons (monocots). The larger branch became the eudicotyledons (eudicots). Monocots get their name from their seeds, which have a single prepacked seed-leaf, or cotyledon. There is no other foolproof way of recognizing a monocot, but there are some strong clues. Most have long narrow leaves with parallel veins, and the flower parts (petals, stamens, and so on) are arranged in threes or multiples of three, and not fours or fives as in most eudicots, and the pollen grains only have a single opening. In many monocot flowers, such as tulips, the sepals and petals are almost identical and known as tepals, but many of the magnoliids share this feature as well.

Below ground, monocots usually have a cluster of fibrous roots, instead of a main taproot with smaller roots leading off it. Another key characteristic—revealed under a microscope—involves the structure of their stems. They have scattered bundles of vascular tissue—the specialized cells that carry water and sap—unlike eudicots, which have theirs in concentric rings. This makes monocot stems more flexible than those of a typical eudicot, but it also makes it harder for them to evolve into trees. Treelike monocots, which principally include palms, have a very different way of growing from typical broad-leaved trees and conifers. Their trunks grow taller, but not thicker, and are usually topped by a single rosette of leaves.

SURVIVAL STRATEGIES

Smaller monocots vary greatly, from climbers to acquatic plants that survive harsh periods as underground storage organs, such as bulbs or tubers. Grasses thrive on the grazing effects of animals, and are the only plant family that forms an entire habitat: grassland. In the tropics, many monocots are epiphytic, growing high up in trees. This group includes bromeliads, and many orchids—by far the largest monocot family, with over 25,000 species worldwide.

DIVISION	ANGIOSPERMAE
CLADE	MONOCOTYLEDONEAE
ORDERS	11
FAMILIES	81
SPECIES	58,000

DEBATE

DID MONOCOTS HAVE AQUATIC ORIGINS?

Living monocots include many freshwater plants, and also some of the few flowering plants that live in the sea. According to a longstanding theory, monocots may have originally evolved in fresh water, before diversifying and taking up life on land. This would account for the long, thin leaves found in many species, and also the internal structure of their stems (see left). Having spread to land, some terrestrial monocots then came full circle and evolved into aquatic forms—duckweeds, for example, originated in this way.

ACORALES

Only one genus and as few as two species make up the order Acorales. Called sweet flags, these waterside and wetland plants have a fleshy flower spike of small flowers and were once classified as aroids (see right). Botanists now believe they represent the earliest branch of the monocot family tree, and may hold clues as to what the first monocots looked like.

3¼ ft/1 m

SWEET FLAG
Acorus calamus
F: Acoraceae

Once cut to strew on floors because of its fresh citrus scent, this waterside plant grows across the Northern Hemisphere.

ALISMATALES

This order includes many common aquatic plants as well as the mainly land-based aroid family (Araceae). Aroids, which can be dramatic in appearance, have a distinctive reproductive anatomy consisting of a fleshy spike of tiny flowers called a spadix and a leaflike surround called a spathe. The other families in the order include many freshwater species, as well as several families of seagrasses.

WATER PLANTAIN
Alisma plantago-aquatica
F: Alismataceae

Found in waterside habitats, this plant is common across the Northern Hemisphere. It has white, pink, or purple flowers that last only a day.

3¼ ft
1 m

elliptical to oval leaves

OVAL FLOATING LEAF

3¼ ft
1 m

BRANCHED FLOWER CLUSTER

WATER HAWTHORN
Aponogeton distachyos
F: Aponogetonaceae

Native to South Africa, this plant has become widely naturalized elsewhere. Its vanilla-scented flowers open just above the water surface.

male flowers

FLOWER STEM

ARROW-SHAPED LEAF

female flowers

3¼ ft/1 m

ARROWHEAD
Sagittaria sagittifolia
F: Alismataceae

This European wetland plant grows arrowhead-shaped leaves above water, ribbonlike ones below water, and sometimes floating leaves too.

13 ft/4 m

GIANT TARO
Alocasia macrorrhizos
F: Araceae

Of uncertain origin, this huge-leaved aroid grows across tropical Asia and the Pacific region, and is cultivated elsewhere as an ornamental.

14 in
35 cm

LORDS AND LADIES
Arum maculatum
F: Araceae

The spadix of this spring-flowering European native heats up to attract pollinating insects. In the fall it produces poisonous red berries.

GLOSSY LEAF

6 in
15 cm

SPATHE

FRIAR'S COWL
Arisarum vulgare
F: Araceae

The spathe of this widespread Mediterranean aroid curves over its spadix like a hood. Its leaves are arrow-shaped.

patterned leaves

10 ft
3 m

DUMBCANE
Dieffenbachia seguine
F: Araceae

This aroid from tropical American forests causes severe swelling and pain if chewed. Houseplant varieties have showy, attractive foliage.

24 in/60 cm

GOLDEN CALLA LILY
Zantedeschia elliottiana
F: Araceae

This showy aroid with yellow flowers is found only in cultivation. Its wild relatives live in South Africa, mainly in wetland habitats.

3½ ft
1 m

feathery roots

WATER LETTUCE
Pistia stratiotes
F: Araceae

Of uncertain origin, this lettuce-sized member of the aroid family floats in warm fresh waters worldwide, often clogging waterways.

SWISS CHEESE PLANT
Monstera deliciosa
F: Araceae

The mature leaves of this tree-climbing aroid from Central America become perforated and divided. It is widely grown as an ornamental.

65 ft/20 m

TARO
Colocasia esculenta
F: Araceae

This large-leaved aroid, native to tropical Asia and the Pacific, has been cultivated extensively since ancient times for its edible tubers.

6½ ft
2 m

20 ft/6 m

SWEETHEART PLANT
Philodendron scandens
F: Araceae

Very common in its native Central America, this fast-growing climbing aroid is also a popular ornamental houseplant.

⅛ in
3 mm

DUCKWEED
Lemna gibba
F: Araceae

Despite appearances, duckweed belongs to the aroid family. This widespread floating plant grows in tiny ovals ⅛ in (3 mm) across.

giant spadix with tiny flowers at base

giant spathe

TITAN ARUM
Amorphophallus titanum
F: Araceae

After its 10-ft (3-m) inflorescence has died down, this giant aroid from Sumatra grows a single, long-lasting, treelike leaf.

3¼ ft
1 m

DRAGON ARUM
Dracunculus vulgaris
F: Araceae

With its dark red spathe and odor of rotting meat, this eastern Mediterranean aroid is well adapted for pollination by flies.

3¼ ft
1 m

COBRA LILY
Arisaema consanguineum
F: Araceae

Native to the eastern Himalayas and China, this summer-flowering aroid has a distinctive striped spathe. The whole plant is very poisonous.

1/16 in
1 mm

SPOTLESS WATERMEAL
Wolffia arrhiza
F: Araceae

Found worldwide, this floating duckweed is the world's smallest flowering plant, forming tiny green ovals ⅛ in (1 mm) long.

3¼ ft
1 m

WESTERN SKUNK CABBAGE
Lysichiton americanum
F: Araceae

Native to wet habitats in western North America, this aroid gives off a strong odor to attract insects.

12 in
30 cm

BOG ARUM
Calla palustris
F: Araceae

This wetland and shallow-water aroid is a popular ornamental. It is native to cool regions of the Northern Hemisphere.

5 ft
1.5 m

FLOWERING RUSH
Butomus umbellatus
F: Butomaceae

A showy waterside plant, flowering rush is the only member of its family native to Eurasia. It is invasive in North America.

»

» ALISMATALES

3¼ ft
1 m

BRAZILIAN ELODEA
Egeria densa
F: Hydrocharitaceae
Native to southeast Brazil, this underwater plant clogs lakes and waterways across the temperate world, requiring expensive control measures.

3¼ ft/1 m

VALLISNERIA AMERICANA
F: Hydrocharitaceae
A freshwater species, this long-leaved underwater plant is widespread in North America. Male flowers break loose, floating until they encounter female ones to pollinate.

3¼ ft
1 m

BROAD-LEAVED PONDWEED
Potamogeton natans
F: Potamogetonaceae
This freshwater plant has broad surface leaves and grasslike underwater ones. It is common across the Northern hemisphere.

3¼ ft/20 cm

FROGBIT
Hydrocharis morsus-ranae
F: Hydrocharitaceae
This free-floating freshwater plant from Europe spreads via horizontal underwater stems. Male and female flowers grow on separate plants.

NEPTUNE GRASS
Posidonia oceanica
F: Posidoniaceae
This Mediterranean sea grass is related to frogbit. Its underwater leaves grow from sea floor stems in depths up to 100 ft (30 m).

tufts of ribbonlike leaves

3¼ ft/1 m

MARINE EEL GRASS
Zostera marina
F: Zosteraceae
Growing on sandy sea floors across the Northern hemisphere, this grasslike plant forms underwater "meadows" that are an important marine habitat.

3¼ ft
1 m

ASPARAGALES

This diverse order includes familiar garden flowers such as daffodils and irises, desert-adapted plants such as agaves, and a few trees. Many of its species used to be classified in the order Liliales, and botanists have relied on genetic techniques to prove that the Asparagales form a single related group. The order also includes the highly specialized orchid family.

32 in/80 cm

ROUND-HEADED LEEK
Allium sphaerocephalon
F: Alliaceae
This European relative of the onion favors limestone soil. Gardeners grow it for its colorful, tightly packed flower heads.

3¼ ft/1 m

ONION
Allium cepa
F: Alliaceae
Evidence from ancient Egypt shows that the onion has been cultivated for at least 5,000 years.

20 in
45 cm

RAMSONS
Allium ursinum
F: Alliaceae
Related to and smelling of garlic, this plant often carpets the floors of European woodlands in spring with its broad green leaves.

24 in
60 cm

AFRICAN LILY
Agapanthus africanus
F: Agapanthaceae
From South Africa, this flower has a long central stalk and its narrow leaves arch. It can survive fires in its native habitat, regrowing from a fleshy underground stem.

8 in
20 cm

SNOWDROP
Galanthus nivalis
F: Amaryllidaceae
The early spring flowers of this shade-tolerant European native have three white sepals that are much longer than the inner petals.

CLIVIA MINIATA
F: Amaryllidaceae
Horticulturalists have bred many varieties of this South African woodland plant for its showy flowers and straplike evergreen leaves.

AMARYLLIS
Hippeastrum sp.
F: Amaryllidaceae
This genus of showy, bulb-forming plants is native to warmer parts of the Americas. Many cultivated varieties and hybrids exist.

DICHELOSTEMMA IDA-MAIA
F: Asparagaceae
Native to Oregon and northern California, this mainly woodland species has attractive tubular flowers that make it popular as a garden plant.

WILD DAFFODIL
Narcissus pseudonarcissus
F: Amaryllidaceae
The ancestor of many cultivated varieties of daffodil, this native European species of mountains and woods is becoming rarer.

ST. BERNARD'S LILY
Anthericum liliago
F: Asparagaceae
This European native with grasslike leaves likes sunny hillsides and other open places. It prefers limestone soil.

CRINUM X POWELLII
F: Amaryllidaceae
This bulb-forming plant is a hybrid of two South African species of *Crinum*. It is hardy in cooler climates.

CENTURY PLANT
Agave americana
F: Asparagaceae
Native to southwestern US and Mexico and, this succulent, or water-retaining plant, flowers once after many years and then dies.

SPIDER PLANT
Chlorophytum comosum
F: Asparagaceae
Forming new plantlets from its leaves and arching stems, this variegated form of an African species is well known as a houseplant.

COMMON ASPARAGUS
Asparagus officinalis
F: Asparagaceae
Cultivated for its tender young shoots (spears), this European species becomes a tall feathery plant if left to grow.

SPANISH DAGGER
Yucca gloriosa
F: Asparagaceae
Like all yuccas, this coastal species from southeastern US relies on a specialized yucca moth for pollination.

JOSHUA TREE
Yucca brevifolia
F: Asparagaceae
Native to the US's Mojave Desert, this woody many-branched yucca is thought to live for hundreds of years.

»

flower stem holds up to 15 flowers

10 in
25 cm

LILY-OF-THE-VALLEY
Convallaria majalis
F: Asparagaceae
A sweetly scented plant from temperate Eurasia, lily-of-the-valley has poisonous red berries.

28 in
70 cm

SOLOMON'S SEAL
Polygonatum multiflorum
F: Asparagaceae
A mainly woodland plant, this Eurasian species has leafy arched stems and tube-shaped scentless flowers.

3¼ ft/1 m

BUTCHER'S BROOM
Ruscus aculeatus
F: Asparagaceae
Flowers and fruits grow straight out of the "leaves" (actually flattened stems) of this shrubby European plant.

24 in
60 cm

CAST-IRON PLANT
Aspidistra elatior
F: Asparagaceae
Native to Japan, this woodland plant is now popular elsewhere. Its small purple flowers bloom close to the soil.

5 ft
1.5 m

SEA SQUILL
Drimia maritima
F: Asparagaceae
Native to Mediterranean coasts, this large-bulbed plant grows a tall spike of white flowers in late summer after its leaves have withered.

12 in
30 cm

STAR-OF-BETHLEHEM
Ornithogalum angustifolium
F: Asparagaceae
This widespread European plant closes its flowers quickly in dull weather. Its narrow grooved leaves have a central white stripe.

24 in
60 cm

MOTHER-IN-LAW'S TONGUE
Sansevieria trifasciata
F: Asparagaceae
This tropical west African species with stiff patterned leaves is a popular houseplant. It is also grown for its fibers.

20 in
50 cm

PORTUGUESE SQUILL
Scilla peruviana
F: Asparagaceae
From southwestern Europe, this showy bulb-forming perennial has long broad leaves growing from the plant's base.

bell-shaped flower

12 in
30 cm

APHYLLANTHES
Aphyllanthes monspeliensis
F: Asparagaceae
When not flowering, this Mediterranean species looks like a clump of rushes, with many slender stems that are almost leafless.

18 in
45 cm

spike of up to 50 fragrant flowers

HYACINTH
Hyacinthus orientalis
'Blue Jacket'
F: Asparagaceae
This is one of many fragrant, colorful varieties derived from a southwest Asian species over many centuries.

12 in
30 cm

CAPE COWSLIP
Lachenalia aloides
F: Asparagaceae
Native to the southwest tip of Africa, this bulb-forming species grows only one or two strap-shaped leaves.

BLUE HOSTA
Hosta 'Halycon'
F: Asparagaceae
This blush-leaved hybrid is one of many garden varieties of *Hosta*, a genus of shade-tolerant plants native to Northeast Asia.

18 in
45 cm

ENGLISH BLUEBELL
Hyacinthoides non-scripta
F: Asparagaceae
Native to western Europe, this bulb-forming plant sometimes carpets whole woodland floors with blue flowers in spring.

18 in
45 cm

SMALL CAMAS
Camassia quamash
F: Asparagaceae
The edible bulbs of this spring-flowering meadowland plant from western North America were a staple food for American Indians.

3¼ ft
1 m

DRAGON TREE
Dracaena draco
F: Asparagaceae
Rare in its native Canary Islands, this many-branched tree survives as a popular ornamental. Its red sap was prized as "dragon's blood."

40 ft
12 m

TASSEL HYACINTH
Muscari comosum
F: Asparagaceae
The flowerheads of this Mediterranean species have fertile and sterile flowers, the latter forming the purplish "tassel" at the top.

24 in
60 cm

32 in
80 cm

COMMON FRINGE LILY
Thysanotus tuberosus
F: Asparagaceae
Native to southeast Australia, this narrow-leaved plant has fringe-petaled flowers that each open for only one day.

65 ft
20 m

CABBAGE TREE
Cordyline australis
F: Asparagaceae
This ornamental tree, shown here as a young plant, bears clusters of scented flowers. It was once an important food source for the Maori people of New Zealand.

FIELD GLADIOLUS
Gladiolus italicus
F: Iridaceae
A Mediterranean member of the iris family, field gladiolus flowers between March and June.

3¼ ft
1 m

3¼ ft
1 m

BEARDED IRIS
Iris x *germanica*
F: Iridaceae
This fragrant hybrid iris, common in gardens, may have originated in southeastern Europe but is now naturalized across the continent.

MONTBRETIA
Crocosmia x *crocosmiiflora*
F: Iridaceae
A 19th-century hybrid created from two South African species, this popular garden plant is invasive in some areas.

24 in
60 cm

3¼ ft
1 m

PALE YELLOW-EYED GRASS
Sisyrinchium striatum
F: Iridaceae
Native to Chile and Argentina, this representative of a large New World genus has pale flowers marked with fine purple stripes.

12 in
30 cm

KEW'S FREESIA
Freesia x *kewensis*
F: Iridaceae
Derived from native South African ancestors, this freesia is a sweet-smelling garden hybrid in the Northern Hemisphere.

24 in
60 cm

24 in
60 cm

GRAND CHRISTMAS BELLS
Blandfordia grandiflora
F: Blandfordiaceae
Nectar-sipping birds seek out this large flower of coastal eastern Australia. Its leaves are narrow and grasslike.

SAFFRON CROCUS
Crocus sativus
F: Iridaceae
The dried stigmas of this cultivated Mediterranean crocus have long been sold as saffron, used for coloring and flavoring food.

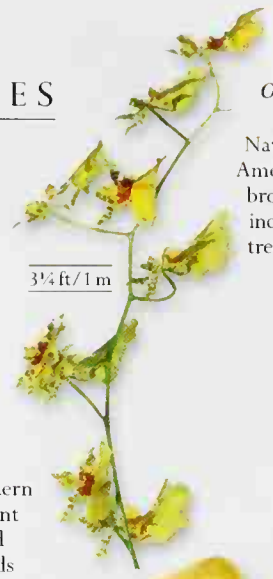
18 in
45 cm

BARBARY NUT
Gynandriris sisyrinchium
F: Iridaceae
This wild Mediterranean iris grows a corm (a bulblike underground stem) to help it survive unfavorable conditions.

»

FAIRY SLIPPER ORCHID
Calypso bulbosa
F: Orchidaceae

Widespread across cooler parts of the Northern Hemisphere, this fragrant single-flowered orchid prefers damp woodlands and marshlands.



***ONCIDIUM* SP.**
F: Orchidaceae

Native to the tropical Americas, this genus of broad-lipped orchids includes around 400 tree-living species of varying sizes.

LESSER BUTTERFLY ORCHID
Platanthera bifolia
F: Orchidaceae

Found in various habitats across temperate Eurasia, this sweetly scented pale-flowered orchid is visited and pollinated by night-flying moths.

PHRAGMIPEDIUM* X *SEDENII
F: Orchidaceae

This fragrant ground-living orchid is a hybrid created from species of the genus *Phragmipedium*, slipper orchids native to tropical regions of the Americas.

TRACY'S CYMBIDIUM
Cymbidium tracyanum
F: Orchidaceae

This epiphytic orchid from Burma, Thailand, and southwest China produces its strongly fragrant flowers in fall.

HYACINTH ORCHID
Dipodium squamatum
F: Orchidaceae

A leafless ground-living Australian orchid, this species depends on associating with underground fungi to survive. It lives in woodland habitats.

PYRAMIDAL ORCHID
Anacamptis pyramidalis
F: Orchidaceae

This chalk-loving orchid from temperate Eurasia sticks its pollen onto visiting butterflies and moths, as first described by Charles Darwin.

PINK LADY'S SLIPPER
Cypripedium acaule
F: Orchidaceae

Widespread in eastern North America, this two-leaved slipper orchid favors acidic soil, as in pine forests.

HAIRY SLIPPER ORCHID
Paphiopedilum villosum
F: Orchidaceae

Native to China and parts of southeast Asia, this slipper orchid has been used to create many ornamental hybrids.

ORANGE GUARIANTHE
Guarianthe aurantiaca
F: *Orchidaceae*

This tree-living species is native to tropical Central America. Many ornamental varieties and hybrids have been bred by horticulturists.

TAIWAN PLEIONE
Pleione formosana
F: Orchidaceae

Native to parts of China, this small ground-living orchid dies back during the winter months.

WAGNER'S MASDEVALLIA
Masdevallia wagneriana
F: Orchidaceae

The sepals of this small epiphytic orchid from the mountains of northern Venezuela have narrow tails, a feature typical of the genus.

RED HELLEBORINE
Cephalanthera rubra
F: Orchidaceae

This ground-living species with rose-pink flowers grows in open woodlands from Europe to central Asia.

VIOLET BIRD'S-NEST ORCHID
Limodorum abortivum
F: Orchidaceae

This European orchid lacks green leaves so its root tips obtain food through *Russula* fungi found alongside it.

32 in / 80 cm

DENDROBIUM SP.
F: Orchidaceae

Including over 1,000 species of diverse shapes, and sizes, this genus of epiphytic orchids is found from southeast Asia to New Zealand.

6½ ft
2 m

LIPPEROSE MOTH ORCHID
Phalaenopsis 'Lipperose'
F: Orchidaceae

This cultivated hybrid is one of many developed using the genus *Phalaenopsis* from southeast Asia with its broad flattened flowers.

3¼ ft
1 m

12 in
30 cm

TONGUE ORCHID
Serapias lingua
F: Orchidaceae

The lip of this unusual Mediterranean orchid's flower hangs down like a tongue, acting as a landing platform for visiting insects.

35 in
90 cm

LIZARD ORCHID
Himantoglossum hircinum
F: Orchidaceae

The long lips of Europe's largest wild orchid have a fanciful resemblance to tiny lizards, resulting in its common name.

three sepals and two petals on each flower

24 in
60 cm

3¼ ft
1 m

SEED POD

FEATHERY EVERGREEN LEAVES

MILITARY ORCHID
Orchis militaris
F: Orchidaceae

This chalk-loving Eurasian orchid may have acquired its name because the individual flowers resemble helmeted human figures.

24 in
60 cm

drooping sepals

12 in
30 cm

COMMON DONKEY ORCHID
Diuris corymbosa
F: Orchidaceae

Native to southern Australia, this orchid gets its common name from the shape of its side petals, which resemble donkeys' ears.

ROTHCHILD'S VANDA
Vanda 'Rothschildiana'
F: Orchidaceae

This cultivated hybrid was created by crossing species of the genus *Vanda*, which are tree-living orchids native to tropical Asia.

FLAT-LEAVED VANILLA ORCHID
Vanilla planifolia
F: Orchidaceae

Native to Mexico and Central America, this climbing orchid is the source of the flavoring vanilla.

lanceolate leaves on each stalk

AUTUMN LADY'S-TRESSES
Spiranthes spiralis
F: Orchidaceae

This small, mainly grassland orchid from temperate Eurasia is notable for its flowers being arranged spirally up the flower stalk.

8 in
20 cm

GREENHOOD ORCHID
Pterostylis sp.
F: Orchidaceae

In this mainly Australian genus of ground-living orchids, the upper sepal often forms a hood over the center of the flower.

flower resembles a fat bumblebee

flower attracts insects

sepal forms protective hood over flower

3¼ ft 1 m

stamen carries pollen

16 in
40 cm

20 in
50 cm

flower lip closes when touched by an insect

14 in
35 cm

DARK RED HELLEBORINE
Epipactis atrorubens
F: Orchidaceae

The long roots of this fragrant Eurasian orchid help it grow successfully even within the cracks of limestone cliffs.

NUN'S ORCHID
Phaius tankervilleae
F: Orchidaceae

This fragrant ground-living orchid is widely cultivated. Its native range is tropical and subtropical southeast Asia and the South Pacific.

BEE ORCHID
Ophrys apifera
F: Orchidaceae

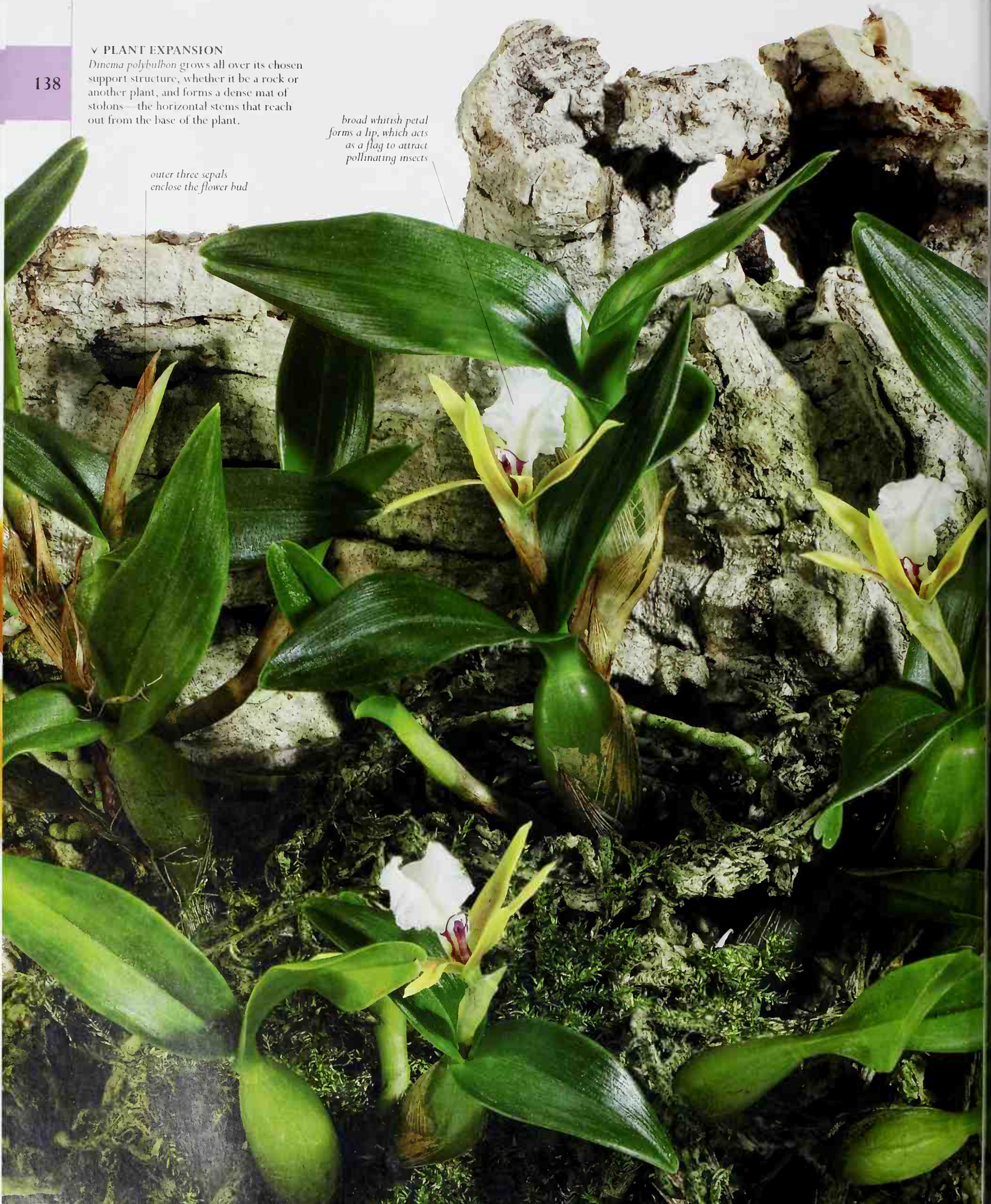
Although in a genus whose flowers attract pollinating male insects by mimicking females, this Eurasian orchid in practice often pollinates itself.

»

v PLANT EXPANSION
Dinema polybulbon grows all over its chosen support structure, whether it be a rock or another plant, and forms a dense mat of stolons—the horizontal stems that reach out from the base of the plant.

broad whitish petal forms a lip, which acts as a flag to attract pollinating insects

outer three sepals enclose the flower bud



MANY-BULBED ORCHID
Dinema polybulbon

This diminutive orchid is the only species in the genus *Dinema*. Rambling and prolific, it is an epiphytic or lithophytic plant, meaning that it grows on trees or rocks, using them for support. It gains its nutrients from the air, animal detritus, or other plant remains, and absorbs water from rain or mist. Moisture collects on the orchid's leaves, which are thick and waxy, and have reduced stomata—all features that help reduce water loss. The leaves funnel water into swollen, upright stems known as pseudobulbs, which are in fact water-storage organs that evolved to keep the orchid hydrated during tropical dry seasons. The pseudobulbs are attached to horizontal stems, which are in turn connected to both underground and aerial roots. These absorb dissolved nutrients through an outer layer of cells called velamen. During winter, each pseudobulb produces a single flower. Hardy in frost to 14°F (−10°C), this species is a favorite of orchid collectors.

SIZE Height 3 in (7.5 cm)
HABITAT Humid, mixed forests
DISTRIBUTION Mexico, Central America, Jamaica, Cuba
LEAF TYPE Parallel veins

flattened leaf tip has a notch

PSEUDOBULB >
These small, oval, bulblike structures, sparsely distributed on a horizontal stem, store water to be used when surface water is scarce.

< AERIAL ROOTS
The orchid's aerial roots grow above ground. The older parts of the root have a protective layer of dead cells that act like blotting paper, helping absorb and retain water.

^ FLOWER
The pseudobulb produces a small, sweet-smelling flower with narrow yellow-brown sepals, purple petals, and a spreading white lip.

< POLLEN SACS
Pollen grains are contained in two sacs. A sticky mass glues the sacs onto the pollinator, which carries the pollen to another plant.

» ASPARAGALES

GRASSTREE
Xanthorrhoea australis
F: Xanthorrhoeaceae

Over time, this bushfire-resistant Australian plant eventually grows into a solidly branched tree. Its tiny flowers are borne on tall spikes.

NEW ZEALAND FLAX
Phormium tenax
F: Hemerocallidaceae

This common New Zealand species grows large leaves at ground level and a tall flower stalk bearing tubular reddish flowers.

DAY LILY
Hemerocallis fulva
F: Hemerocallidaceae

Each flower of this ornamental species lasts one day. Native to East Asia, it is widely naturalized in North America.

COMMON ASPHODEL
Asphodelus aestivus
F: Asphodelaceae

This common narrow-leaved Mediterranean plant produces many white or yellow flowers on a tall stem.

MEDICINAL ALOE
Aloe vera
F: Asphodelaceae

This spiny succulent adapted to dry areas has been cultivated since ancient times for its reputed medicinal properties.

TORCH LILY
Kniphofia uvaria
F: Asphodelaceae

Native to the southwest tip of Africa, this multiflowered plant with long narrow leaves is now a popular ornamental specimen.

LILIALES

Many plants once considered part of the lily family, including onions and hyacinths, have recently been moved into a completely separate order, the Asparagales (see pp.132–39). The trimmed-down Liliales includes the true lilies, their close relatives the tulips, and various other plants including alstroemerias. Many are colorful bulb-forming species while some are climbers.

WILD TULIP
Tulipa sylvestris
F: Liliaceae

Still widespread in its native Europe, this yellow-flowered tulip, a relative of the cultivated garden tulip grows wild in meadows, rocky hillsides, as well as open woodland.

HERB PARIS
Paris quadrifolia
F: Liliaceae

Found in ancient woodland in temperate Eurasia, this four-leaved plant has a single green flower that develops into a black inedible fruit.

SNAKESHEAD FRITILLARY
Fritillaria meleagris
F: Liliaceae

This bulb-forming European species has distinctive chequered flowers. It grows wild in damp meadows but is more common in cultivation.

BOG ASPHODEL
Narthecium ossifragum
F: Nartheciaceae

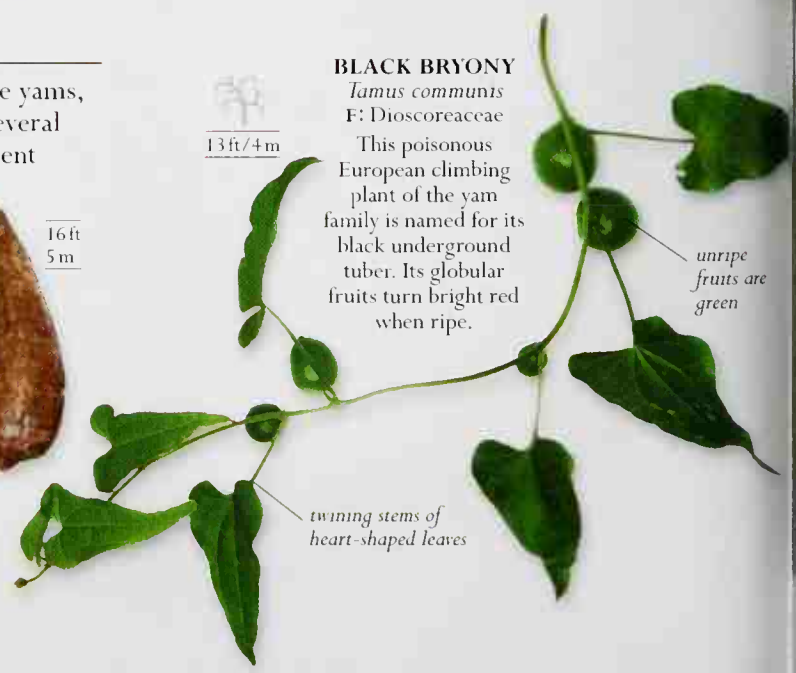
This European plant lives in nutrient-poor upland habitats. As its seeds develop, the flowerhead becomes a fiery orange color.

DIOSCOREALES

This relatively small order is dominated by the yams, a family of mainly tropical climbing plants. Several species of yam have been cultivated since ancient times for their large edible tubers. The order also contains a few lilylike plants such as bog asphodel.

YAM
Dioscorea sp
F: Dioscoreaceae

Widely cultivated in the tropics, yams grow large, starch-rich tubers. Plants have stems that trail or climb and heart-shaped leaves.



BLACK BRYONY
Tamus communis
F: Dioscoreaceae

This poisonous European climbing plant of the yam family is named for its black underground tuber. Its globular fruits turn bright red when ripe.

MADONNA LILY
Lilium candidum
F: Liliaceae

Often encountered in Christian art as a symbol of purity, this widely cultivated lily is native to the eastern Mediterranean.

3½ ft
1 m

female stigma receives the pollen

male stamens carry the pollen

GAGEA RETICULARIS
F: Liliaceae

This small bulb-forming plant grows in open habitats across much of temperate Asia, as well as southeast Europe and North Africa.

6 in
15 cm

TURK'S CAP LILY
Lilium martagon
F: Liliaceae

This widespread Eurasian lily has the reflexed (backward-bending) tepals that form the flower shape characteristic of the species.

4 ft
1.2 m

FLAME LILY
Gloriosa superba
F: Colchicaceae

This striking plant from South African woodlands is a climber, clambering upwards with the aid of tendrils.

6½ ft / 2 m

FLOWERHEADS

6 in
15 cm

MEADOW SAFFRON
Colchicum autumnale
F: Colchicaceae

The crocuslike flowers of this European native appear in the autumn, months before its leaves. Despite being poisonous, it is cultivated widely.

TYPICAL LEAF

10 ft
3 m

GIANT HIMALAYAN LILY
Cardiocrinum giganteum
F: Liliaceae

Found from the Himalayas to China, this giant lily grows for several seasons before flowering, after which the main plant dies.

flower with six tepals

leaf twists from stem so underside appears uppermost

leaves arranged spirally up stem

up to 40 tubular flowers

CALDAS' BOMAREA
Bomarea caldasii
F: Alstroemeriaceae

This showy-flowered climbing plant is a close relative of alstroemerias. It is native to South America.

13 ft
4 m

PERUVIAN LILY
Alstroemeria sp.
F: Alstroemeriaceae

This lilylike South American genus includes many popular ornamentals. The leaves twist during growth to become anatomically upside-down.

4 ft
1.2 m

»

» LILIALES

CHILEAN BELLFLOWER
Lapageria rosea
F: Philesiaceae
Cultivated for its spectacular bell-shaped flowers, this is native to humid woodlands of Chile.

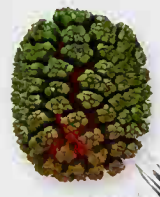
BERRIES

SMILAX
Smilax aspera
F: Smilacaceae
Native to the Mediterranean and southwest Asia, this climber has male and female flowers on separate plants.

FALSE HELLEBORE
Veratrum sp.
F: Melanthiaceae
Native to the Northern Hemisphere, this genus of poisonous plants produces branched flowerheads of often greenish flowers.

PANDANALES

Found mainly in the tropics, this order includes over 1,300 species of trees, shrubs, climbers, and smaller plants. Many look superficially like palms, except that they have simpler, strap-shaped leaves. Around half of them belong to the single genus *Pandanus* (screw pines).


MULTI-SEEDED FRUIT

SCREW PINE
Pandanus tectorius
F: Pandanaceae
No relation of real pines, this tropical coastal tree has long been a vital source of materials for Pacific Island cultures.

ARECALES

This order is made up of one large family, the palm trees. Growing typically from one central bud, palms vary from small shrubs to towering trees. There are also many species of slender climbing rattans. The huge leaves of palm trees are either feather-shaped or fan-shaped. Although they may conjure up an image of deserts or sandy beaches, most species actually live in tropical rain forests.

SUGAR PALM
Arenga pinnata
F: Arecaceae
This native of India and southeast Asia grows showy yellow flowerheads. It yields products including sugar and fibers.

DATE PALM
Phoenix dactylifera
F: Arecaceae
Seen here as a young tree, this cultivated palm from the Middle East grows as separate male and female trees.

BETEL NUT PALM
Areca catechu
F: Arecaceae
Cultivated for its seeds, which release a psychoactive substance when chewed, this palm originates from southeast Asia.

SINGLE-SEEDED FRUIT

COCONUT PALM
Cocos nucifera
F: Arecaceae
Now widely cultivated, this species probably originated in the western Pacific, colonizing new islands via its floating fruits.

DESERT FAN PALM
Washingtonia filifera
F: Arecaceae
Dead leaves below this palm's crown provide shelter for desert birds and insects of its native southwestern United States.

PETTICOAT PALM
Copernicia macroglossa
F: Arecaceae
Native to Cuba, this relatively small palm is named for the skirt of dead leaves that it retains below its crown.

AFRICAN OIL PALM
Elaeis guineensis
F: Arecaceae

A plant of humid tropical lowlands, this palm is extensively cultivated beyond its native Africa for the oils contained in its fruits.

BOTTLE PALM
Hyophorbe lagenicaulis
F: Arecaceae

This swollen-based palm comes from tiny Round Island near Mauritius. It is widely grown as an ornamental.

CHUSAN PALM
Trachycarpus fortunei
F: Arecaceae

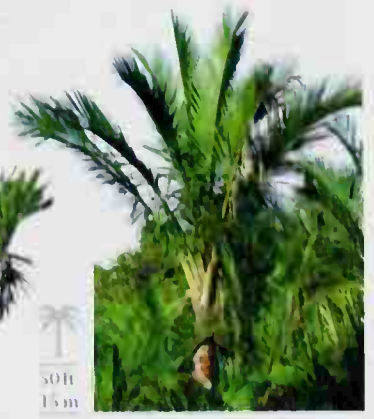
From China, this cold-tolerant species has separate male and female plants. The females produce round blue-black fruits.

COCO DE MER
Lodoicea maldivica
F: Arecaceae

The seeds of this palm from the Seychelles are the biggest in the plant kingdom. They take six years to mature.

ROYAL PALM
Roystonea regia
F: Arecaceae

Avenues of this handsome smooth-trunked species are common in the tropics. Native to Caribbean islands, it thrives on rich soils.



SAGO PALM
Metroxylon sagu
F: Arecaceae

Shown here as a young plant, this swamp-living palm probably originated in New Guinea but now grows throughout southeast Asia.

RAFFIA PALM
Raphia farinifera
F: Arecaceae

At 65 ft (20 m) long, the leaves of this African and Madagascan palm are the largest of any tree.

PALMYRA PALM
Borassus flabellifer
F: Arecaceae

This tall-trunked species from southern Asia favors drier habitats. It is cultivated for its fruit and sugar-yielding sap.

BRAZILIAN WAX PALM
Copernicia prunifera
F: Arecaceae

This palm from central and northeast Brazil has brown flowers. The wax coating on its leaves is harvested commercially.

EUROPEAN FAN PALM
Chamaerops humilis
F: Arecaceae

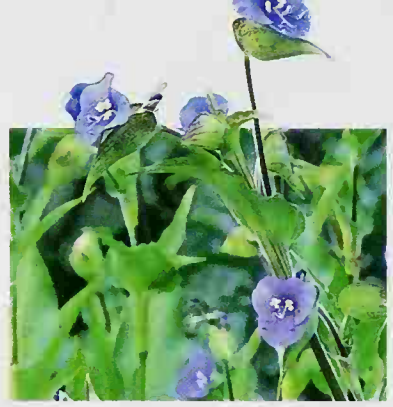
Often trunkless in the wild, cultivated specimens grow several short trunks from a single base. It originates from Mediterranean countries.

CHILEAN WINE PALM
Jubaea spectabilis
F: Arecaceae

Also known as the coquito palm, this massive-trunked, cold-tolerant palm is native only to central Chile, where it is now a protected species.

COMMELINALES

This order includes a variety of mainly low-growing plants, typically from the warmer regions of the world. Many have attractive three-petaled blue flowers (reduced to two petals in some species), making them popular as ornamentals. Their leaves and stems are also often fleshy, with a sticky sap that hardens on exposure to air.



24 in
60 cm

BLUE SPIDERWORT
Commelina coelestis
F: Commelinaceae
Sometimes planted as ground cover, this sprawling plant is native to Mexico and Central America.

QUEEN'S SPIDERWORT
Dichorisandra reginae
F: Commelinaceae
A popular garden flower grown in warmer regions, this tropical woodland species is from Peru. It has blue flowers with white centers.

10 cm
4 in

TURTLE VINE
Callisia repens
F: Commelinaceae
This succulent creeping plant from forest edges in the American tropics spreads by rooting from stems.

trailing stems

2¼ ft
70 cm

TAHITIAN BRIDAL VEIL
Tripogandra multiflora
F: Commelinaceae
This native of Central and South America has weak stems and leaves with purple undersides.

6 in
15 cm

INCH PLANT
Tradescantia zebrina
F: Commelinaceae
With striped, succulent foliage, this ground-living species from the tropical Americas is also a popular houseplant.

12 in
30 cm

POALES

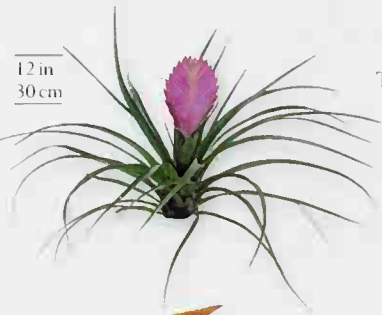
Grasses dominate the order Poales. Their wind-pollinated flowers have no need of showy petals. Sedges and rushes also belong in this order, as do the bromeliads, which are mainly epiphytic, meaning they live on but do not feed off other plants. Many produce brightly colored flower spikes that emerge from rosettes of tough, broad leaves.

18 in
45 cm

SCARLET STAR
Guzmania lingulata
F: Bromeliaceae
This tree-living bromeliad has a wide native range from Central America to Brazil. It is a popular ornamental species.

12 in
30 cm

SLENDER CLUB-RUSH
Isolepis cernua
F: Cyperaceae
With narrow green stems and silvery flowerheads, this widespread temperate sedge is also dubbed "fiber-optics grass."



12 in
30 cm

PINK QUILL
Tillandsia cyanea
F: Bromeliaceae
Native to Ecuador, pink quill grows on trees, in forests between 2,000 ft and 3,300 ft (600–1,000 m) above sea level.

long, narrow leaves

5 ft
1.5 m

12 in
30 cm

red bracts surround flowers

BIRD'S-NEST BROMELIAD
Nidularium innocentii
F: Bromeliaceae
The small flowers of this Brazilian bromeliad nestle within the chamber formed by the surrounding colored bracts. *Nidularium* means "little nest."

PINEAPPLE
Ananas comosus
F: Bromeliaceae
Christopher Columbus first introduced Europeans to this cultivated bromeliad with its large fruit. It probably originates from Brazil.

arching stalk of flower cluster

cluster of separate flowers

14 in
35 cm

vaselike rosette of leaves collects rainwater

DYER'S TILLANDSIA
Tillandsia dyeriana
F: Bromeliaceae
This epiphytic bromeliad is endangered in the wild due to destruction of its native mangrove forests in Ecuador.

spiny-leaved rosettes

10 in
25 cm

LORENTZ'S BROMELIAD
Deuterocohnia lorentziziana
F: Bromeliaceae
Native to the high, dry Andes of Argentina, this is a ground-dwelling bromeliad.

BLUSHING BROMELIAD
Neoregelia carolinae
F: Bromeliaceae
At flowering time, the central leaves of this Brazilian bromeliad turn crimson, and it produces blue or violet flowers.

10ft/3m

TALL KANGAROO PAW
Anigozanthos flavidus
F: Haemodoraceae
From sandy areas of southwestern Australia, this species gets its common name from the appearance of its woolly-haired flower buds.

flowers in compact conical cluster

yellow blotch on uppermost petal of each flower

18in
45cm

swollen leaf stalk

COMMON WATER HYACINTH
Eichhornia crassipes
F: Pontederiaceae
Native to Amazonia, this floating plant is a major tropical pest, but can be used to absorb pollution.

3¼ft/1m

PICKEREL WEED
Pontederia cordata
F: Pontederiaceae
Fast-growing and with striking blue flowerheads, this water-edge species is common across eastern North America and has become invasive elsewhere.

spike of male flowers

PENDULOUS SEDGE
Carex pendula
F: Cyperaceae
Like other true sedges (genus *Carex*), this European species has triangular stems and separate male and female flower clusters.

4½ft
1.4m

spike of female flowers

6½ft
2m

CHINESE WATER CHESTNUT
Eleocharis dulcis
F: Cyperaceae
Native to eastern Asia, this wetland sedge has tall, leafless stems. It is cultivated for its edible underwater tubers.

16ft/5m

PAPYRUS SEDGE
Cyperus papyrus
F: Cyperaceae
This tall African perennial is a wetland plant. The Ancient Egyptians wrote on a paperlike material called papyrus made from its leaves.

main central leaves

giant spike of more than 3,000 flowers

evergreen variegated foliage

3¼ft
1m

yellow bracts around small white flowers

33ft
10m

stiff, spiny leaves

ZEBRA PLANT
Aechmea chantinii
F: Bromeliaceae
This large spiny-leaved epiphytic bromeliad comes from the rain forests of South America. It is pollinated by hummingbirds.

HAHN'S CATOPSIS
Catopsis hahnii
F: Bromeliaceae
This epiphytic bromeliad is native to the cloud forests of southern Mexico and Central America.

20in
50cm

rosette of strap-shaped leaves

gray-green leaves with waxy texture

QUEEN OF THE ANDES
Puya raimondii
F: Bromeliaceae
Native to the central Andes, the world's largest bromeliad produces a single colossal flower spike after many years of growth and then dies.

» POALES

SOFT RUSH
Juncus effusus
F: Juncaceae

This very widespread rush thrives in damp infertile soil. Its cylindrical stems are filled with spongy tissue, or pith.

5 ft
1.5 m

4½ ft
1.3 m

LARGE QUAKING GRASS
Briza maxima
F: Poaceae

This annual grass from Europe gets its name from the way its fine-stalked flower heads shake at the slightest breeze.

24 in
60 cm

FALSE OAT-GRASS
Arrhenatherum elatius
F: Poaceae

Common across its native Europe, this tall-flowered wild relative of the oat has now spread to many other parts of the world.

6 ft
1.8 m

SAND COUCH
Elytrigia juncea
F: Poaceae

This tough grass grows on the seaward side of European sand dunes. Its roots, or rhizomes, help to hold the windblown sand together to form dunes.

24 in
60 cm

CRESTED DOG'S-TAIL
Cynosurus cristatus
F: Poaceae

Low-growing apart from its flower stalks, this perennial grass from Europe and west Asia resists trampling and is often used for lawns.

30 in
75 cm

COCK'S-FOOT
Dactylis glomerata
F: Poaceae

Often grown in hay fields and pastures, this common grass with distinctive tufty flower heads is native to Eurasia and North Africa.

8¼ ft
2.5 m

JOB'S TEARS
Coix lacryma-jobi
F: Poaceae

This cereal grass is native to tropical Asia but is widely grown elsewhere. The seeds of one variety are traded as beads for jewelry.

young seeds

DRIED SEED HEAD

14 in
35 cm

HARE'S TAIL
Lagurus ovatus
F: Poaceae

The distinctive soft-haired flower heads of this mainly coastal Mediterranean grass make it popular in dried flower arrangements.

20 ft
6 m

TALL, BROAD LEAF

GIANT REED
Arundo donax
F: Poaceae

Originally from central Asia, this outsize marshland grass has been widely planted elsewhere. Its woody stems have many traditional uses.

EVERGREEN LEAVES

15 ft
5 m

BLACK BAMBOO
Phyllostachys nigra
F: Poaceae

Like all the bamboos, this black-stemmed species has hard woody stems. It is native to east and South China. Bamboos are the fastest growing woody plant, growing up to 24 in (60 cm) a day.

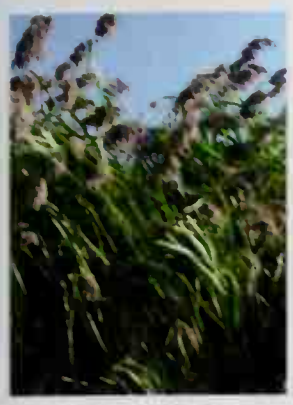
FINGER-THICK CANE

awns protect seeds

THREE-AWNED GOAT GRASS
Aegilops neglecta
F: Poaceae

A relative of wheat, this low-growing, drought-resistant annual grass is native to Eurasia and parts of Africa.

14 in
35 cm



20 ft
6 m

COMMON REED
Phragmites australis
F: Poaceae

Widespread in both temperate and tropical regions, this shallow-water grass can colonize large areas via its creeping horizontal stems.

3¼ ft
1 m

SWEET VERNAL GRASS
Anthoxanthum odoratum
F: Poaceae

Native to Eurasia, this early-flowering grass contains a chemical called coumarin that makes it smell pleasantly of fresh-mown hay.

4 ft
1.2 m

MARRAM GRASS
Ammophila arenaria
F: Poaceae

This tough grass from Europe flourishes on sand dunes, which its long underground stems and roots help to stabilize.

6 ft
1.8 m

OAT
Avena sativa
F: Poaceae

This cultivated grass, grown widely as a cereal crop for livestock and human consumption, thrives in cool, wet climates.

3¼ in
80 cm

BARLEY
Hordeum vulgare
F: Poaceae

Originating in the ancient Near East, this cultivated cereal grass is notable for the long hairlike bristles (awns) on its flower heads.

3¼ ft
1 m

BREAD WHEAT
Triticum aestivum
F: Poaceae

The world's top-tonnage cereal, this species originated in the ancient Near East. It is a hybrid of both the wild and the earlier cultivated wheats.

16 in
40 cm

CREEPING BENT-GRASS
Agrostis stolonifera
F: Poaceae

This common perennial grass with feathery flower heads is found worldwide. It spreads using creeping horizontal stems, or stolons.

9¾ ft
3 m

CITRONELLA
Cymbopogon nardus
F: Poaceae

A type of lemongrass, citronella originates from tropical Asia. It yields an oil used in perfumes and for repelling insects.

9¾ ft
3 m

VETIVER
Chrysopogon zizanioides
F: Poaceae

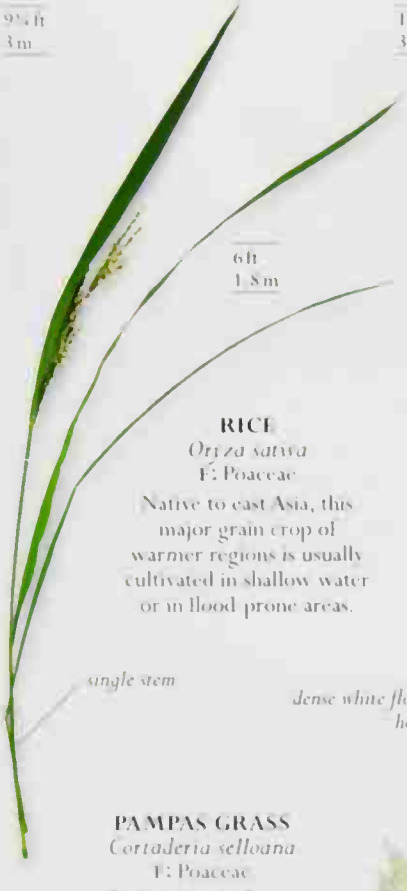
Native to India, this tropical grass is widely cultivated for its fragrant oil and to bind soils to prevent erosion.

PERENNIAL RYE-GRASS
Lolium perenne
F: Poaceae

Much used in pastures, lawns, and sports fields, this common Eurasian grass has now spread around the world.

YORKSHIRE FOG
Holcus lanatus
F: Poaceae

A common European grass found in damp meadows, Yorkshire fog has leaves with soft velvety hairs.



6 ft
1.8 m

RICE
Oryza sativa
F: Poaceae

Native to east Asia, this major grain crop of warmer regions is usually cultivated in shallow water or in flood-prone areas.

10 ft
3 m

20 ft
6 m

MAIZE
Zea mays
F: Poaceae

This major food crop was first cultivated in ancient Mexico. It has male or female flower heads—edible corn is the female flower.

SUGAR CANE
Saccharum officinarum
F: Poaceae

Possibly related to maize, this tropical cultivated grass may have originated in New Guinea. Sugar is extracted from its thick stems.

PAMPAS GRASS
Cortaderia selloana
F: Poaceae

This tall grass from southern South America is a popular ornamental species. It has become invasive in some areas.

9¾ ft
3 m

»

» POALES

8 ft
2.5 m

GIANT FEATHER GRASS
Stipa gigantea
F: Poaceae

Gardeners cultivate this tall grass for its showy flowerheads, which persist until winter. It is native to Spain and Portugal.

female flower

male flower heads

5 ft
1.5 m

BRANCHED BUR-REED
Sparganium erectum
F: Sparganiaceae

Separate ball-shaped clusters of male and female flowers develop on the same flower stalk in this widespread wetland species of the Northern Hemisphere.

10 ft
3 m

12 in
30 cm

CATTAIL
Typha latifolia
F: Typhaceae

This common Northern Hemisphere wetland plant has a distinctive cigar-shaped female flowerhead. The male flowers grow above it in a tuft.

YELLOW-EYED GRASS
Xyris sp.
F: Xyridaceae

This genus of grasslike plants, widespread in warmer regions of the world, bears small yellow flowers on slender stems.

ZINGIBERALES

A feature of this mainly tropical order is that many species grow giant leaves at the end of stalks. Although there are no true woody trees, some species such as the banana plant grow very large. Many Zingiberales have showy flowers and foliage and have become ornamentals. The ginger family, Zingiberaceae, is the largest in the order, includes several other important spice plants beside ginger itself.

16 in
40 cm

LOVELY PRAYER PLANT
Ctenanthe amabilis
F: Marantaceae

Native to forest floors in the Brazilian tropics, this warmth-loving plant requires high humidity if grown in cultivation.

3¼ ft
1 m

ETERNAL FLAME
Calathea crocata
F: Marantaceae

Related to *Ctenanthe* and *Maranta*, this Brazilian species has more striking flowers than its relatives although living in similar forest habitats.

6½ ft
2 m

INDIAN SHOT
Canna indica
F: Cannaceae

This South American plant has unusual flowers in which some of the "petals" are actually modified pollen-producing stamens. There are many cultivated varieties.

24 in
60 cm

SPIRAL FLAG
Chamaecostus igneus
F: Costaceae

This orange-flowered relative of the ginger family is native to tropical eastern. Brazil, and is also grown as an ornamental.

12 in
30 cm

SILVER-VEINED PRAYER PLANT
Maranta leuconeura
F: Marantaceae

This Brazilian forest plant folds its leaves together at night to conserve moisture. Cultivated varieties have strikingly patterned foliage.

40 ft/12 m

ENSET
Ensete ventricosum
F: Musaceae

This African-relative of the banana has long been cultivated in Ethiopia for its nutritious rootstock and stem, not its (inedible) fruit.

30 ft
9 m

BANANA
Musa acuminata
F: Musaceae

The seedless hybrid of Asian wild ancestors, cultivated bananas grow sterile male flowers at the end of their fruiting branches.

24 in/60 cm

each yellow bract protects four or five tiny flowers

CHINESE YELLOW BANANA
Musella lasiocarpa
F: Musaceae

Possibly extinct in the wild, this mountain species from China produces a yellow flower spike that can last for months.

VIOLET-STRIPED WHITE FLOWER

5.5m 18ft

LANCEOLATE LEAF

SEED POD

CARDAMOM
Elettaria cardamomum
F: Zingiberaceae
This tropical plant is native to forests in South India and Sri Lanka, but cultivated elsewhere. Its seeds are the spice cardamom.

WHITE FLOWER

5ft 1.5m

LESSER GALANGAL
Alpinia officinarum
F: Zingiberaceae
Native to South China, this relative of ginger develops a swollen underground stem and is similarly used as a spice.

1.2m 30cm

AROMATIC GINGER
Kaempferia galanga
F: Zingiberaceae
Native to tropical Asia, this short-stemmed species develops small flowers and is grown as an ornamental.

paddle-shaped leaves, green at tip, yellow at leaf stem

RHIZOME AND ROOTS

FLESHY RHIZOME

3¼ft 1m

TURMERIC
Curcuma longa
F: Zingiberaceae
Native to S.E. Asia, this large-leaved plant develops a swollen underground stem from which the yellow spice turmeric is obtained.

STEM WITH FLOWER HEAD

symmetrical fan-shaped tree

EDIBLE RHIZOME

3¼ft 1m

GINGER
Zingiber officinale
F: Zingiberaceae
The spice called ginger is the underground stem of a leafy Southeast Asian plant that is now known only from cultivation.

50ft 15m

TRAVELLER'S TREE
Ravenala madagascariensis
F: Strelitziaceae
Native to open forests in Madagascar, this relative of *Strelitzia* is pollinated by lemurs in its natural habitat.

6½ft 2m

BIRD-OF-PARADISE
Strelitzia reginae
F: Strelitziaceae
Orange-and-blue bird-pollinated flowers open one at a time from a beaklike sheath in this South African plant.

purple flowers develop in summer

10in 25cm

HUME'S ROSCOEA
Roscoea humeana
F: Zingiberaceae
This relative of the ginger plant grows unusual orchidlike flowers. Its native habitat is the mountains of Southwest China.

12ft 4m

HELICONIA STRICTA
F: Heliconiaceae
In its natural habitat, this large-leaved tropical plant from northern areas of South America is pollinated by nectar-sipping hummingbirds.

EUDICOTYLEDONS

About three-quarters of all the world's current flowering plants are classified in the eudicotyledon grouping, which evolved over 125 million years ago.

Eudicots get their name from the cotyledons, or seed-leaves, in the seed before it germinates. Unlike monocots, which have a single seed-leaf, eudicots have two. They include an enormous variety of plants, from agricultural weeds to towering rain forest trees, and they are of huge economic importance, as well as being prized as garden flowers. Many eudicots are annuals, with short life spans measured in months or even weeks. Others are biennials and perennials, which live from two years to a century or more.

Despite their great diversity, eudicots have many physical features in common. Their leaves often have a netlike tracery of veins, unlike the parallel veins of monocots, and their stems have well-developed vascular systems, arranged in rings, for transporting water and sap. As well as getting taller, woody species thicken and strengthen their stems as they grow. This "secondary growth" is absent in most monocots, which is why eudicots make up most of the world's flowering shrubs and trees. Below ground level, most eudicots have a taproot, with smaller roots branching off from it.

Eudicot flowers usually have parts in fours or fives, rather than the threes found in monocots, with sepals and petals that look different, both in color and in shape. Each species has its own distinctive kind of pollen, the grains always have three pores; monocots pollen grains only have a single opening.

A VITAL ROLE

The fossil pollen record suggests that the eudicots diverged from other flowering plants some 125 million years ago. Since then, they have colonized every land habitat, although they are less common as water plants and absent from the sea. Their importance to animals is impossible to overestimate. Countless species—with the notable exception of grazing animals, which feed on grasses (monocots)—depend on them for food and shelter, and many act as pollinators, or help to spread seeds.

DIVISION	ANGIOSPERMAE
CLADE	EUDICOTYLEDONAE
ORDERS	38
FAMILIES	307
SPECIES	182,227

DEBATE

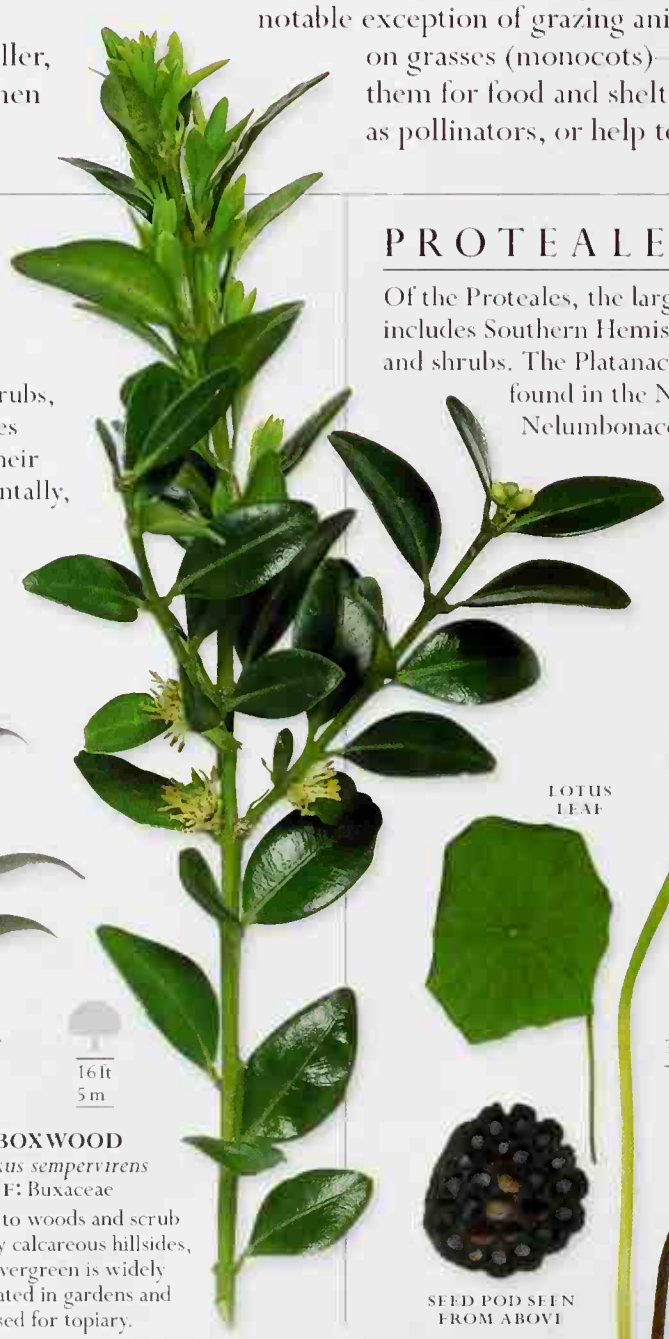
FOUR-WAY SPLIT

For many years, all flowering plants were classified in two groups—the monocotyledons (monocots) and the dicotyledons (dicots)—based on the number of their seed-leaves. However, DNA analysis, combined with palynology—the study of pollen—has shown that this classification does not fully reflect plant evolution. As a result, flowering plants are now split into four overall groups: basal angiosperms, magnoliids, monocots, and the eudicots, or true dicots.

BUXALES

Containing two families, the order Buxales is distributed in temperate, tropical, and subtropical regions. The majority of the species are trees and shrubs, characterized by simple evergreen leaves without leaflike stalks, or stipules, at their bases. Many species are grown ornamentally, and boxwood is used for carving.

SWEET BOX
Sarcococca hookeriana
F: Buxaceae
This species bears clusters of small fragrant flowers in winter, and is found in shady habitats in western China.

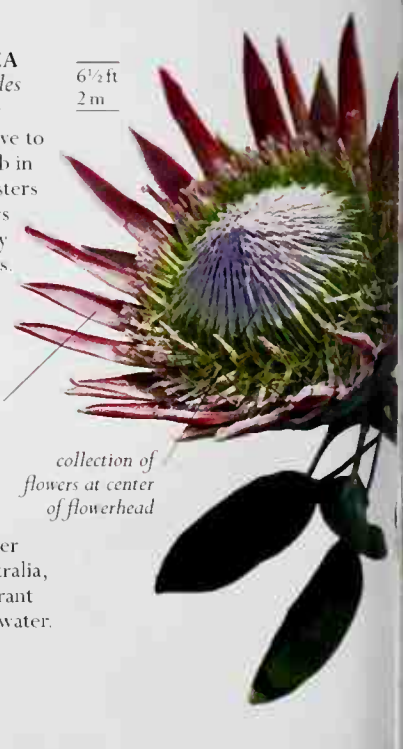


BOXWOOD
Buxus sempervirens
F: Buxaceae
Native to woods and scrub on rocky calcareous hillsides, this evergreen is widely cultivated in gardens and used for topiary.

PROTEALES

Of the Proteales, the largest family, Proteaceae, includes Southern Hemisphere evergreen trees and shrubs. The Platanaceae are deciduous trees found in the Northern Hemisphere. Nelumbonaceae are aquatic plants from Asia, Australia, and North America.

SAW BANKSIA
Banksia serrata
F: Proteaceae
Saw Banksia grows in woodlands and scrub in Australia. Its bark is fire-resistant, enabling it to survive bush fires.



KING PROTEA
Protea cynaroides
F: Proteaceae
This species is native to hillsides and scrub in South Africa. Clusters of small flowers are enclosed by petal-like bracts.

SACRED LOTUS
Nelumbo nucifera
F: Nelumbonaceae
Growing in shallow freshwater habitats in parts of Asia and Australia, sacred lotus carries large, fragrant flowers on long stalks above the water.

simple, evergreen leaf

leafy spike of red or occasionally yellow or white flowers

30 ft / 10 m

CHILEAN FIRE BUSH
Embothrium coccineum
F: Proteaceae

From forest and open habitats in southern Chile, this species is cultivated for its flame-colored flowers, and thrives in sheltered gardens.

2 m / 6 ft

CONE BUSH
Isopogon anemonifolius
F: Proteaceae

Spherical flowerheads above feathery leaves characterize this native of dry woodlands and heathlands. Cone bush is found in New South Wales, Australia.

UNRIPE NUTS

FLOWER SPIKE

MACADAMIA NUT
Macadamia integrifolia
F: Proteaceae

Macadamia is native to coastal rainforest in Australia and is cultivated for its edible nuts.

65 ft / 20 m

2 ft / 2 m

KAHILI FLOWER
Grevillea banksii
F: Proteaceae

Cultivated as an ornamental species for its striking "bottle-brush" flowers, this native of Australia grows in woods and open habitats

6½ ft / 2 m

MOUNTAIN DEVIL
Lambertia formosa
F: Proteaceae

From coastal and montane heathlands and forest in New South Wales, Australia, this species has pink-tinged bracts surrounding the flower clusters.

sepals

115 ft / 35 m

SILKY OAK
Grevillea robusta
F: Proteaceae

This fast-growing species from the Australian rainforest bears one-sided clusters of flowers, which have brightly colored leathlke sepals in place of petals.

6½ ft / 2 m

RED PINCUSHION PROTEA
Leucospermum cordifolium
F: Proteaceae

This South African species is noted for its brightly colored, spherical flowerheads. It grows in acidic soil.

10 ft / 3 m

WARATAH
Telopea speciosissima
F: Proteaceae

From dry woodlands in New South Wales, Australia, common waratah is also known as Sydney waratah.

fruit takes about six months to ripen

thick, stiff textured, broad leaf, similar to maple

100 ft / 30 m

LONDON PLANETREE
Platanus x hispanica
F: Platanaceae

Planted in London since the 17th century, this deciduous hybrid arose from the cross-fertilization of two species of *Platanus* in Spain. Tolerant of pollution, it is widely planted in urban parks and streets.

RANUNCULALES

Annual and perennial herbaceous species, woody and herbaceous climbers, shrubs, and trees are all included in the order Ranunculales, named after the buttercup family, Ranunculaceae, which contains the greatest number of species in the order. Many of the genera are familiar ornamental garden plants, including clematis species, columbines, poppies, delphiniums, and anemones.

10 ft
3 m

oval, toothed leaf

oblong berry

BARBERRY
Berberis vulgaris
F: Berberidaceae
A European species of hedges and scrub, barberry has distinctive triple spines, hanging flower clusters, and red berries.

12 in
30 cm

BISHOP'S HAT
Epimedium davidii
F: Berberidaceae
This evergreen from western China grows in woods and scrub. The young leaves are coppery, later turning green.

EVERGREEN LEAF

BRIGHT RED BERRIES

SACRED BAMBOO
Nandina domestica
F: Berberidaceae
This species grows in mountain valleys in India, China, and Japan. It is also known as heavenly bamboo.

6½ ft
2 m

CHOCOLATE VINE
Akebia quinata
F: Lardizabalaceae
Bearing sprays of scented flowers in spring, chocolate vine inhabits forest edges in China, Korea, and Japan.

twining stem

33 ft
10 m

20 ft
6 m

MOONSEED
Menispermum canadense
F: Menispermaceae
Although the fruits of this climber resemble black grapes, they are extremely poisonous. The species inhabits woodland and banks of streams in Canada and USA.

flower cluster

20 in
50 cm

13 ft
4 m

fragrant flower

CAROLINA SNAILSEED
Cocculus carolinus
F: Menispermaceae
This climbing woodland species from southeast USA has tiny flowers; the males and females are borne on separate plants.

30 in
75 cm

PINNATE LEAF

CREAMY-COLOURED FLOWER

CLIMBING CORYDALIS
Ceratocapnos claviculata
F: Papaveraceae
This scrambling European species grows in woods and shady habitats on acid soils, supporting itself through its leaf tendrils.

LEONTICE
Leontice leontopetalum
F: Berberidaceae
Native to cultivated ground and dry hillsides in North Africa and eastern Mediterranean countries, leontice grows from a tuber.

16 in/40 cm

MAY APPLE
Podophyllum peltatum
F: Berberidaceae
A native of North America, May apple—also known as American mandrake—grows in open woodland.

33 ft/10 m

JAPANESE STAUNTON VINE
Stauntonia hexaphylla
F: Lardizabalaceae
Native to woodland in Japan and South Korea, this vigorous evergreen climber has woody stems and fragrant flowers.

12 in
30 cm

YELLOW CORYDALIS
Corydalis lutea
F: Papaveraceae
This European species grows on walls and in stony and rocky places. It spreads vigorously by seed.

36 in
90 cm

GREATER CELANDINE
Chelidonium majus
F: Papaveraceae
Formerly grown by herbalists, greater celandine is native to Europe and northern Asia, growing in woodland, scrub, and rocky places.

36 in
90 cm

YELLOW HORNED POPPY
Glaucium flavum
F: Papaveraceae
Native to much of Europe and western Asia, yellow horned poppy usually inhabits coastal shingle. Its long curved fruits are distinctive.

4 ft
1.2 m

BLEEDING HEART
Dicentra spectabilis
F: Papaveraceae
Named for its heart-shaped flowers, it grows in damp woodland edges in Siberia, northern China, and Korea.

spurred petal

PINNATE LEAF

18 in
45 cm

WELSH POPPY
Meconopsis cambrica
F: Papaveraceae
Inhabiting shady, rocky places in hilly areas and often grown in gardens, Welsh poppy is native to western Europe.

YELLOW OR ORANGE FLOWER

12 in
30 cm

CALIFORNIA POPPY
Eschscholzia californica
F: Papaveraceae
A species of open habitats in western USA and Mexico, California poppy is grown in for its brightly colored flowers.

12 in
30 cm

COMMON FUMITORY
Fumaria officinalis
F: Papaveraceae
Found in most of Europe on cultivated and waste ground, this species usually grows on light soils.

pollen produced by a ring of dark central anthers

8 in
20 cm

SICKLEFRUIT HYPECOUM
Hypecoum imberbe
F: Papaveraceae
This native of southern Europe grows in cultivated and waste ground and on walls.

24 in
60 cm

cut stem exudes poisonous latex

COMMON POPPY
Papaver rhoeas
F: Papaveraceae
Arable and waste ground are home to this poppy, native to Europe, North Africa, and parts of Asia. It is used as a symbol to commemorate World War I.

OPIUM POPPY
Papaver somniferum
F: Papaveraceae
Grown as the source of opium, heroin, and poppy seed, this inhabits cultivated and disturbed ground in Eurasia.

20 in
50 cm

MATILIJA POPPY
Romneya coulteri
F: Papaveraceae
A species of scrub and grassland in California and Mexico, this poppy has fragrant flowers and is often grown in gardens.

6½ ft
2 m

»

PHEASANT'S EYE
Adonis annua
F: Ranunculaceae

An increasingly uncommon annual species, pheasant's eye is found in cultivated and waste ground in southern Europe and southwest Asia.

MEADOW BUTTERCUP
Ranunculus acris
F: Ranunculaceae

Found in much of Europe and temperate regions of western Asia, this perennial species is found in damp grassland.

TRAVELER'S JOY
Clematis vitalba
F: Ranunculaceae

Also known as "old man's beard" for its gray feathery fruit, traveler's joy is a woody climber found in wood edges and hedgerows in Europe and North Africa.

WINTER ACONITE
Eranthis hyemalis
F: Ranunculaceae

This tuberous perennial is found in damp woodland and shady places in central Europe. It flowers in late winter (hence its common name) and early spring.

ROCKET LARKSPUR
Consolida ambigua
F: Ranunculaceae

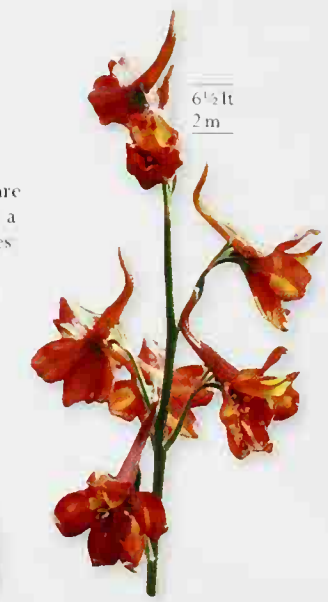
Growing on cultivated and disturbed ground on light soils, rocket larkspur is an annual native to the Mediterranean region.

KINGCUP
Caltha palustris
F: Ranunculaceae

Kingcup, or marsh marigold, inhabits marshes, ditches, wet woods, and wet grassland in much of Europe, Asia, and North America.

CROWN ANEMONE
Anemone coronaria
F: Ranunculaceae

Mediterranean countries are home to crown anemone, a tuberous perennial species which grows on stony hillsides, roadsides, and cultivated ground.



SCARLET LARKSPUR
Delphinium cardinale
F: Ranunculaceae

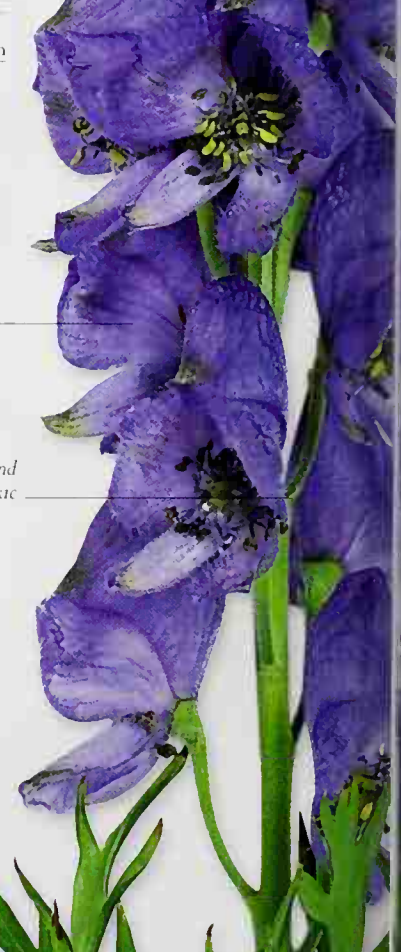
Also known as cardinal larkspur where it grows in California, USA, and Baja California, Mexico, this short-lived perennial is found on dry hillsides.

COMMON MEADOW RUE
Thalictrum flavum
F: Ranunculaceae

This perennial species grows in wet meadows and fens beside freshwater in Europe and temperate regions of Asia.

PASQUE FLOWER
Anemone pulsatilla
F: Ranunculaceae

Chalk slopes with short turf are the home of pasque flower, a perennial species native to central Europe and western Asia.



MONKSHOOD
Aconitum napellus
F: Ranunculaceae

Named for its helmeted flowers, monkshood inhabits damp woods and streamsides in Europe. It is an extremely poisonous perennial species.

HELLEBORE
Helleborus lividus
F: Ranunculaceae
The Balearic Islands, particularly Majorca, are home to this perennial species. Hellebore inhabits woods and rocky hillsides.

GLOBEFLOWER
Trollius europaeus
F: Ranunculaceae
Native to north and central Europe and western Asia, this perennial species is found in damp mountain pasture.

HEPATICA
Anemone hepatica
F: Ranunculaceae
Native to much of Europe, this perennial woodland species has distinctive semievergreen three-lobed leaves.

COLUMBINE
Aquilegia vulgaris
F: Ranunculaceae
A perennial species native to much of Europe, North Africa, and temperate regions of Asia, columbine is found in shady and damp chalky habitats.

OREGON GRAPE
Mahonia aquifolium
F: Berberidaceae
Flowering in springtime, Oregon grape is a suckering evergreen shrub from northwest USA. It grows in shady habitats.

MOUSETAIL
Myosurus minimus
F: Ranunculaceae
The "tail" of mousetail is its elongated fruit. This annual species grows on bare damp ground in parts of Europe, North Africa, and Asia.

GUNNERALES

The two families which make up the Gunnerales order were previously classified in different orders because they are visually very different. However, genetic analysis has recently shown the two families to be closely related. The family Gunneraceae consists of a single genus of large herbaceous plants growing in damp habitats, whereas Myrothamnaceae species are inhabitants of African deserts. *Gunnera* species are often grown in gardens as ornamental plants.

GUNNERA
Gunnera manicata
F: Gunneraceae
Massive leaves and tall flower spikes characterize this perennial species. It is found beside fresh water in Brazil and Colombia.

DILLENIALES

The order Dilleniales was originally thought to contain the family Dilleniaceae and the family Paeoniaceae. It now only contains the Dilleniaceae, a family of trees, shrubs, and climbers found in tropical regions. Most species have alternately arranged leaves and bisexual flowers (with male and female parts) with five sepals, five petals, and numerous stamens. Some produce dry fruit that open to shed their seeds; others have berries.

GOLDEN GUINEA VINE
Hibbertia scandens
F: Dilleniaceae
A vigorous climber or scrambler, this evergreen shrub is found in Australia, often growing near the coast.

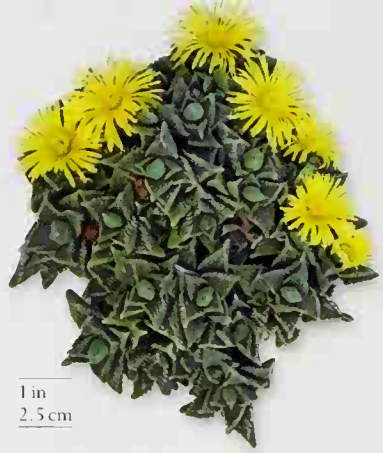
SIMPOH AIR
Dillenia suffruticosa
F: Dilleniaceae
A large and vigorous evergreen shrub endemic to Malaysia, Sumatra, and Borneo, simpoh air is found on swampy ground and forest edges.

CARYOPHYLLALES

An extremely diverse order, the Caryophyllales include trees, shrubs, climbers, succulents, and herbaceous species, and range from carnations to cacti. Most members exist in dry conditions, but many have developed various special adaptations enabling them to survive difficult environments. Perhaps the most extreme example of this is the ability of carnivorous species to trap and digest insects for extra nutrients.

CONOPHYTUM MINUTUM
F: Aizoaceae

A minute, clump-forming species, with fleshy pebble-like leaves, *Conophytum minutum* inhabits semidesert areas in South Africa.



WARTY TIGER JAWS
Faucaria tuberculosa
F: Aizoaceae

Native to semidesert areas of South Africa this species has leaves that resemble an open mouth, hence the name.

PURPLE DEWPLANT
Disphyma crassifolium
F: Aizoaceae

This procumbent species—with stems that trail along the ground—has fleshy leaves and daisylike flowers. Native to South Africa, Australia, and New Zealand, it lives on saline soils.

SCHWANTESIA RUEDEBUSCHII
F: Aizoaceae

A clump-forming species with unequal pairs of keeled fleshy leaves, this succulent grows on hillsides in Namibia and South Africa.

***LAMPRANTHUS* SP.**
F: Aizoaceae

This species of succulent plants from South Africa grows in semidesert areas, particularly near the coast. The numerous daisylike flowers are brightly colored.

TITANOPSIS CALCAREA
F: Aizoaceae

Inhabiting semidesert areas of South Africa, this clump-forming succulent has fleshy leaves. It flowers in late summer and autumn.

LIVING STONES
Lithops aucampiae
F: Aizoaceae

Growing among pebbles in semidesert regions of South Africa, this dwarf clump-forming species has fleshy leaves.

HOTTENTOT FIG
Carpobrotus edulis
F: Aizoaceae

This sprawling, fleshy South African species with showy flowers and edible figlike fruit grows in open dry habitats, where it can be invasive.

ICE PLANT
Mesembryanthemum crystallinum
F: Aizoaceae

Popularly named ice plant for the tiny glistening swellings covering the entire plant, this species inhabits saline areas in parts of Africa, Europe, and western Asia.

FAIRY ELEPHANT'S FEET
Fruthia pulchra
F: Aizoaceae

A minute succulent, *Fruthia pulchra* inhabits temperate open ground in South Africa. The barrel-shaped fruits open after rain to release their seeds.

GIBBAEUM VELUTINUM
F: Aizoaceae

Pairs of unequal-sized fleshy leaves, joined near their bases, characterize this mat-forming species. It is found in semidesert areas in South Africa.

8 ft / 2.5 m

LOVE-LIES-BLEEDING
Amaranthus caudatus
F: Amaranthaceae

Believed to originate in South America, this edible species of various habitats has been used as a source of food since ancient times.

35 in
90 cm

POLPALA
Aerva lanata
F: Amaranthaceae

With catkinlike flower clusters, this perennial native from tropical regions of Asia and Africa grows on dry and waste ground.

40 in
75 cm

ACHYRANTHES BIDENTATA
F: Amaranthaceae

Forest edges, streamsides, and moist shady places in China, Japan, India, and Nepal are home to this species.

ANNUAL SEABLITE
Suaeda maritima
F: Amaranthaceae

Mainly coastal, inhabiting salt marshes in Europe, but growing inland in parts of Asia and North America, annual seablite has green leaves that turn red.

panicles of tiny flowers

3¼ ft
1 m

SEA PURSLANE
Halimione portulacoides
F: Amaranthaceae

Salt marshes, especially edges of tidal channels and pools, are home to sea purslane, a sprawling silvery species from parts of Europe, Africa, and Asia.

12 in
30 cm

COMMON GLASSWORT
Salicornia europaea
F: Amaranthaceae

Common glasswort is a bushy species of muddy salt marshes in western Europe. Its succulent stems are sometimes cooked as a vegetable.

5 ft
1.5 m

HEART-SHAPED LEAF

TALL, LEAFY STEM

SEA BEET
Beta vulgaris
F: Amaranthaceae

The wild ancestor of garden beets, sea beet is a fleshy inhabitant of bare ground by the sea in parts of Europe, North Africa, and Asia.

white, pink, or lilac flower

paired fleshy leaf

PURPLE FLOWER SPIKE

EDIBLE SALAD LEAF

4 ft
1.2 m

RED ORACHE
Atriplex hortensis
F: Amaranthaceae

This spinachlike species with edible leaves grows on seashores and in saline (salty) habitats, and is originally from Asia.

24 in
60 cm

PLUMED COCKSCOMB
Celosia argentea
F: Amaranthaceae

This showy plant lives on dry slopes and stony ground in tropical regions of Africa, Asia, and America. It is often grown in gardens.

3¼ ft
1 m

MEXICAN TEA
Dysphania ambrosioides
F: Amaranthaceae

A short-lived inhabitant of cultivated and waste ground in tropical America, this aromatic species is used as a seasoning and in tea.

»

» CARYOPHYLLALES

PARODIA GRAESSNERI
F: Cactaceae
This cactus has a spherical stem and funnel-shaped flowers. It inhabits mountainous parts of South America.

6 in
15 cm

spines protect slow-growing plant

ERIOSYCE SUBGIBBOSA
F: Cactaceae
This spherical species grows in dry stony places, often at the coast in its native Chile.

12 in
30 cm

unstalked flower

4 in/10 cm

5 ft
1.5 m

PERUVIAN OLD MAN CACTUS
Espostoa lanata
F: Cactaceae
Identified by long white hairs on the columnar stem, this is a slow-growing species from hilly areas of Peru and southern Ecuador.

16 in
40 cm

BARREL CACTUS
Echinocactus sp.
F: Cactaceae
Native to northern Argentina, this is a barrel-shaped species of stony ground and rocky hillsides.

flesh in leaves stores water

23½ in
60 cm

CLEISTOCACTUS BROOKEI
F: Cactaceae
With semierect or spreading fleshy single stems, this cactus species inhabits mountainous areas of Bolivia.

23½ in/60 cm

LEUCHTENBERGIA PRINCIPIS
F: Cactaceae
The stem of this species is either spherical or short and cylindrical, and bears fragrant flowers. It inhabits hilly regions of northern Mexico.

39 ft
12 m

OLD MAN CACTUS
Cephalocereus senilis
F: Cactaceae
Long white hairs on the stem give this cactus its common name. It is native to rocky areas in Mexico.

REBUTIA HELIOSA
F: Cactaceae
A clump-forming species with brightly colored flowers, this native of Bolivia grows in partially shaded mountainous habitats.

GOLDEN COLUMN
Weberbauerocereus johnsonii
F: Cactaceae
This is a tall species from Peru, where it inhabits sandy soil.

13 ft/4 m

20 ft
6 m

52 ft
16 m

arms, or branches, develop to assist fertilization

SAGUARO CACTUS
Carnegiea gigantea
F: Cactaceae
Living for up to 150 years in desert areas of Arizona, California, and in Mexico, saguaro cactus is an extremely tall species.

MISTLETOE CACTUS
Rhipsalis baccifera
F: Cactaceae
Mistletoe cactus is epiphytic—grows on another plant—and lives in tropical America, Madagascar, Sri Lanka, and tropical Africa.

3¼ ft
1 m

16 ft
5 m

49 ft
15 m

PACHYCEREUS PRINGLEI
F: Cactaceae
This very tall branching treelike species inhabits semidesert areas of Mexico. Its flowers open at night.

HARRISIA JUSBERTII
F: Cactaceae
Of uncertain origin, but probably native to hilly areas of Argentina or Paraguay, *Harrisia jusbertii* is a columnar night-flowering cactus.

PACHYCEREUS SCHOTTII
F: Cactaceae
A tall slow-growing species from southern Arizona, this species has unpleasant-smelling flowers which open at night.

6 in
15 cm

MATUCANA INTERTEXTA
F: Cactaceae
Mountainous regions of Peru and Bolivia are home to this clump-forming species with a spherical or short cylindrical stem.

14 in
35 cm

ASTROPHYTUM ORNATUM
F: Cactaceae
A spherical or columnar stem with long brownish-yellow protective spines characterizes this species. It grows in arid areas of Mexico.

12 in/ 30 cm

CLARET CUP HEDGEHOG
Echinocereus triglochidiatus
F: Cactaceae
Growing in deserts, scrub, and on rocky slopes in the southern US and northern Mexico, this variable cactus is pollinated by hummingbirds.

flower bud

5 ft
1.5 m

RAT'S-TAIL CACTUS
Aporocactus flagelliformis
F: Cactaceae
Living on trees or rocks in wooded areas of Mexico, rat's-tail cactus has trailing fleshy stems and colorful flowers.

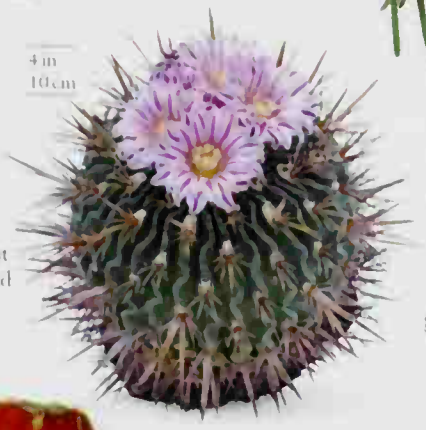
photosynthesis takes place through stems

8 in
20 cm

TURK'S CAP CACTUS
Melocactus salvadorensis
F: Cactaceae
With a characteristic flower-bearing structure on top of a spherical stem when mature, turk's cap cactus inhabits open rocky ground in northeast Brazil.

8 in
20 cm

OLD LADY CACTUS
Mammillaria hahniana
F: Cactaceae
Growing in semidesert regions, old lady cactus is a Mexican species with grayish hairs on the spherical stem.



4 in
10 cm

STENOCACTUS MULTICOSTATUS
F: Cactaceae
This spherical species inhabits shady places in lowland areas of northeast Mexico. The funnel-shaped flowers have faintly striped petals.

6 in
15 cm

GYMNOCALYCIUM HORSTII
F: Cactaceae
This spherical clump-forming cactus grows on rocky hillsides in Argentina, Uruguay, Paraguay, and parts of Brazil.

12 in
30 cm

CRAB CACTUS
Schlumbergera truncata
F: Cactaceae
An epiphytic winter-flowering species of tropical rain forest in southeast Brazil, crab cactus is often grown as a houseplant.

4 in
10 cm

GLORY OF TEXAS
Thelocactus bicolor
F: Cactaceae
Native to arid regions of Texas and northeast Mexico, this is a spherical species.

newly formed prickly pear fruit

16 ft/ 5 m

cluster of spines

PRICKLY PEAR
Opuntia ficus-indica
F: Cactaceae
With flattened jointed stems and edible egg-shaped fruit, prickly pear is a native of rocky hillsides and dry ground in Mexico, and is often naturalized elsewhere.

BRIGHT YELLOW FLOWERS

PADDLE-LIKE GREEN STEM

»

v SPIKY HAIRY STAR
Viewed from above, *Astrophytum ornatum* resembles a star. The flower is surrounded by groups of spines on the eight ribs, showing the cross bands of white, woolly stem hairs.

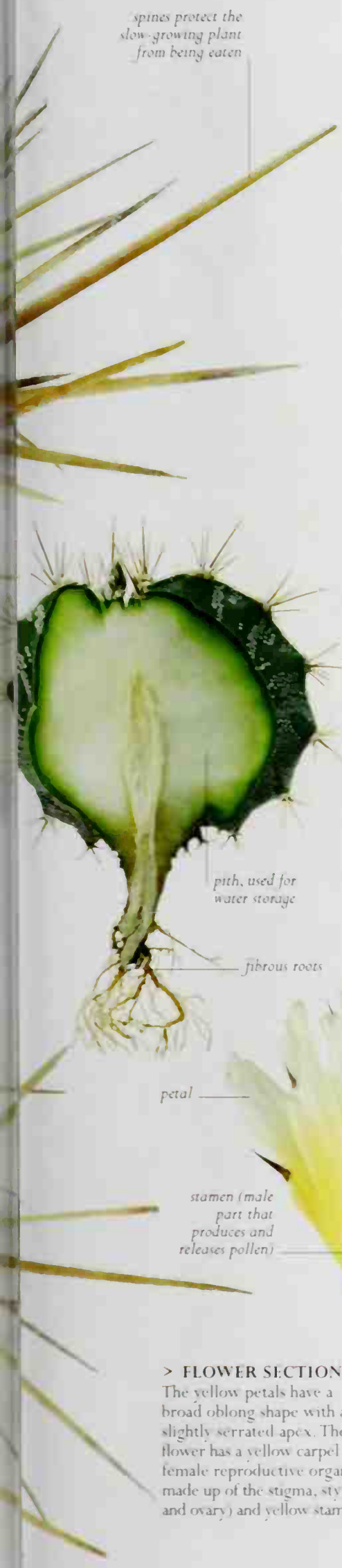
spines grow from a small hollow, or areole, surrounded by white hair

CACTUS
Astrophytum ornatum

spines protect the slow-growing plant from being eaten

Commonly known as the Monk's Hood Cactus, this cactus's genus name means "star plant" in ancient Greek. *Astrophytum ornatum* was first collected in 1827 by Thomas Coulter, an Irish doctor and botanist, who sent it to Professor de Candolle at the Botanic Garden of Geneva. When de Candolle unpacked the cactus he thought it was covered in fungus, but discovered that the white spots were actually tufts of hair or trichomes. These woolly scales may help the cactus collect water and protect it against the sun, but they also provide camouflage. *Astrophytum ornatum* is the most densely covered of all the *Astrophytum* cacti, and also the spiniest. This cactus is now rare in the wild.

SIZE 4 ft (1.2 m)
HABITAT Hot, arid zones
DISTRIBUTION Mexico
LEAF TYPE Spines


pith, used for water storage
fibrous roots
petal
stamen (male part that produces and releases pollen)
stigma
style (female part that connects the stigma to the ovary)
ovary

< ROOT SYSTEM
Fibrous and shallow roots help the cactus absorb water from a large area, essential in an environment where after brief showers only an inch or two of soil is wet.

OUTER PETALS >
The numerous, narrow outer petals of the flower are pale yellow and have brown tips. The flower itself grows to 4¼ in (11 cm) in diameter.

< v STEM HAIRS
This type of cactus exhibits woolly, white tufts of trichomes arranged in bands across the ribs. This stem hair is usually dense in young plants and more sparse in older plants.

^ OVARY
Located below all the other reproductive parts of the flower, the ovary contains ovules that develop into seeds.

^ STIGMA
The flower has a single stigma with seven to twelve lobes. This is the part of the flower used to catch pollen. The stigma is about ½ in (1.5 cm) long.

> FLOWER SECTION
The yellow petals have a broad oblong shape with a slightly serrated apex. The flower has a yellow carpel (the female reproductive organs, made up of the stigma, style, and ovary) and yellow stamens.

» CARYOPHYLLALES

DEPTFORD PINK
Dianthus armeria
F: Caryophyllaceae
Inhabiting dry grassland, especially on light sandy soil in much of Europe, Deptford pink has starry flowers with toothed petals.

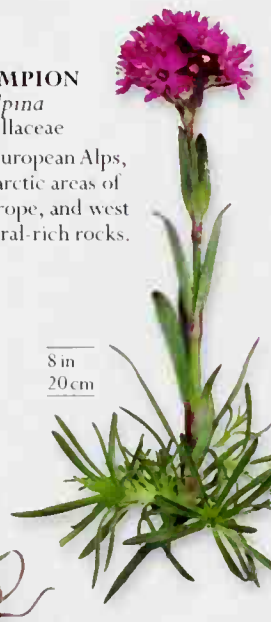
CORNCOCKLE
Agrostemma githago
F: Caryophyllaceae
A native of eastern Mediterranean countries, corncockle was formerly a widespread cornfield weed, but is now much rarer.

COW BASIL
Vaccaria pyramidata
F: Caryophyllaceae
From cultivated and waste ground in parts of Europe and Asia, cow basil has pinkish flowers and bluish green leaves.

SEA SANDWORT
Honckenya peploides
F: Caryophyllaceae
A fleshy prostrate species, sea sandwort is found on coastal sand and pepple in North America, Europe, and Asia.

THYME-LEAVED SANDWORT
Arenaria serpyllifolia
F: Caryophyllaceae
Found in bare or disturbed ground in Europe, temperate Asia, and North America, this species gets its common name from its tiny leaves.

ALPINE CAMPION
Lychnis alpina
F: Caryophyllaceae
This native of the European Alps, Pyrenees, and subarctic areas of North America, Europe, and west Asia grows on mineral-rich rocks.

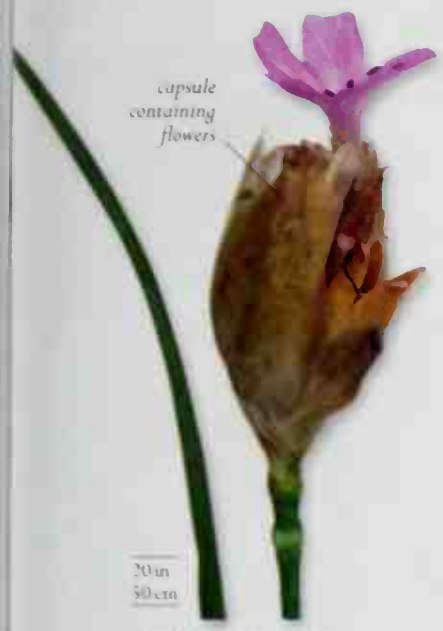


RAGGED ROBIN
Lychnis flos-cuculi
F: Caryophyllaceae
Divided petals give ragged robin its name. It is a European species found in marshy fields and damp ground.

FIELD MOUSE-EAR
Cerastium arvense
F: Caryophyllaceae
A native of dry grassland in North America, Europe, North Africa, and western temperate Asia.

MOSS CAMPION
Silene acaulis
F: Caryophyllaceae
Cushion-forming and mosslike, this grows on mountains in North America, western, central, and northern Europe, as well as Asia.

BLADDER CAMPION
Silene vulgaris
F: Caryophyllaceae
Named for its inflated calyx, Bladder campion inhabits open grassy places in Europe, North Africa, and temperate regions of Asia.



CHILDING PINK
Petrorhagia nanteuilii
F: Caryophyllaceae

The flowers of childing pink open one at a time. This species inhabits dry grassy places in sandy soil in much of Europe.

SOAPWORT
Saponaria officinalis
F: Caryophyllaceae

Once used to make soap, this species is found along streams and damp ground in Europe and Asia.

COMMON CHICKWEED
Stellaria media
F: Caryophyllaceae

This sprawling species is found on cultivated and open ground worldwide and is sometimes used as a salad vegetable.

ROUND-LEAVED SUNDEW
Drosera rotundifolia
F: Droseraceae

Inhabiting open boggy moorland and meadows in North America, Europe, and northern Asia, this insectivorous species has leaves with numerous sticky hairs covered in insect-dissolving enzymes.

VENUS FLY-TRAP
Dionaea muscipula
F: Droseraceae

An insectivorous perennial species from coastal bogs in North and South Carolina, Venus fly-trap has hinged, two-lobed leaves.

BOUGAINVILLEA
Bougainvillea glabra
F: Nyctaginaceae

What seem to be petals on bougainvillea are actually bracts. This slow-growing evergreen climber from Brazil is widely cultivated.

SEA HEATH
Frankenia laevis
F: Frankeniaceae

A mat-forming species, sea heath grows in bare sandy ground in the drier parts of salt marshes in Europe and western Asia.

FOUR O'CLOCK FLOWER
Mirabilis jalapa
F: Nyctaginaceae

From dry open habitats in tropical Central and South America, this species has fragrant flowers which open during the late afternoon.

PITCHER PLANT
Nepenthes vogelii
F: Nepenthaceae

Found in the montane and submontane forests of Borneo, this insectivorous species grows on tree moss.

»

12 in/30 cm

ERIOGONUM UMBELLATUM
F: Polygonaceae

Inhabiting well-drained montane forest and scrub in northern and western US and Canada, this spreading mat-forming species has long-lasting flowers.

6½ ft/2 m

ST. CATHERINE'S LACE
Eriogonum giganteum
F: Polygonaceae

With clusters of tiny long-lasting flowers much visited by butterflies, St. Catherine's lace is native to arid areas of the Southwest US.

23½ in
60 cm

BLACK BINDWEED
Fallopia convolvulus
F: Polygonaceae

Growing on waste and cultivated ground, black bindweed is native to much of Europe, North Africa, and temperate Asia.

3¼ ft/1 m

WAVY-EDGED LEAF

3¼ ft
1 m

SEED STALK

23½ in
60 cm

CURLED DOCK
Rumex crispus
F: Polygonaceae

Curled dock inhabits grassy places, waste ground, and coastal pebbles in Europe and most of Africa. It can be an invasive species.

KNOTGRASS
Polygonum aviculare
F: Polygonaceae

This spreading species of open cultivated and bare ground in Europe and Asia grows on coasts and inland.

reddish flowers pollinated by wind

small, green flowers

SEED STALK

ROUND LEAF

fleshy, kidney-shaped leaves

12 in
30 cm

COMMON BUCKWHEAT
Fagopyrum esculentum
F: Polygonaceae

Buckwheat originated in temperate areas of Asia, and is cultivated for its seeds, which are made into flour and also fed to birds.

35 in
90 cm

39 ft
12 m

9¾ ft
3 m

MOUNTAIN SORREL
Oxyria digyna
F: Polygonaceae

Inhabiting damp ledges and streamsides on mountains in Arctic and temperate regions of the Northern Hemisphere, mountain sorrel is often tinged red.

COMMON BISTORT
Persicaria bistorta
F: Polygonaceae

Inhabiting grassy areas in much of Europe and central Asia, common bistort has dense cylindrical flower spikes.

CORAL VINE
Antigonon leptopus
F: Polygonaceae

This fast-growing species climbs by means of tendrils. It lives in tropical forest and scrub in Mexico.

POKEWEED
Phytolacca americana
F: Phytolaccaceae

With poisonous blackberrylike fruit this unpleasant-smelling perennial is native to open and shady parts of eastern North America and Mexico.

8¼ ft
2.5 m

CHINESE RHUBARB
Rheum palmatum
F: Polygonaceae

With enormous roots and large, poisonous leaves, Chinese rhubarb inhabits streamsides and damp ground in mountainous areas in China and Tibet.

large leaf supported by strong stem

12 in
30 cm

SPRING BEAUTY
Claytonia perfoliata
F: Portulacaceae

Also known as miner's lettuce, this native of cultivated and bare ground in western North America, Mexico, and Cuba has two fused leaves beneath the flowers.

2 in
5 cm

TALINUM OKANOGANENSE
F: Portulacaceae

The flowers of this prostrate species open in the afternoon. Dry grassland and scrub in western North America are its home.

LEWISIA BRACHYCALYX
F: Portulacaceae
Native to damp stony meadows in mountainous areas of southwestern US, this species has a basal rosette of fleshy leaves.

SUMMER PURSLANE
Portulaca oleracea
F: Portulacaceae
Inhabiting many parts of the world including much of Europe, China, and Japan, purslane is an edible fleshy species of disturbed ground.

CALANDRINIA FELTONII
F: Portulacaceae
Now found in the Falkland Islands, but also in gardens, this species is from open rocky or grassy areas in Argentina.

CEYLON LEADWORT
Plumbago zeylanica
F: Plumbaginaceae
Inhabiting open areas and thickets, Ceylon leadwort is native to tropical regions of Africa, the Middle East, and southwestern Asia.

STATICE
Limonium sinuatum
F: Plumbaginaceae
Statice has winged branching stems and is found in rocky and sandy coastal habitats and in saline areas inland in Mediterranean countries.

SEA PINK
Armeria maritima
F: Plumbaginaceae
In much of Western Europe, thrift, or sea pink, inhabits coastal rocks and cliffs, salt marshes, and mountains. It is a cushion-forming species.

TAMARISK
Tamarix gallica
F: Tamaricaceae
Usually coastal, tamarisk also grows in saline areas inland. It originates from southern Europe, North Africa, and the Canary Islands, and is planted elsewhere.

JOJOBA
Simmondsia chinensis
F: Simmondsiaceae
Deserts in Arizona and California and Mexico are home to jojoba, a species often cultivated for its oil.

SANTALALES

Found mainly in tropical and subtropical regions, the order Santalales includes many species of parasitic and semiparasitic plants, such as mistletoe, which grow attached to other plants from which they obtain water and nutrients. Although it is DNA analysis that determines their classification, most of the order have seeds lacking an outer covering. Santalales classification is still being debated.

SANDALWOOD
Santalum album
F: Santalaceae
Cultivated for its wood and fragrant oil, this semiparasitic species grows in dry rocky areas in parts of Asia.

FIRE TREE
Nuytsia floribunda
F: Loranthaceae
This species is semiparasitic, deriving moisture and nutrients from the roots of surrounding plants in woodland in southwestern Australia.

MISTLETOE
Viscum album
F: Santalaceae
Mistletoe forms spherical masses on tree branches. A semiparasitic species with white berries, it inhabits much of Europe, North Africa, and Asia.

OSYRIS
Osyris alba
F: Santalaceae
This broomlike semiparasitic species with fragrant flowers is native to southern Europe, North Africa, and southwest Asia, inhabiting dry rocky places.

SAXIFRAGALES

The order Saxifragales is named after saxifrages. The Latin name *saxifraga* literally means "rock breaker," because these plants often grow in cracks in rocks and walls. Other prominent members of the order are currants, the *Ribes* species, hydrangeas, and the stonecrops *Crassula*. Stonecrops are succulents, or water-retaining plants, adapted to dry conditions.There are over 1,000 species and many are grown as indoor plants.

2 in
5 cm

MEXICAN FIRECRACKER
Echeveria setosa
F: Crassulaceae
Named for its brightly colored flowers, this Mexican species has rosettes of succulent leaves densely covered with white hairs.

6 in
15 cm

CRASSULA DECEPTOR
F: Crassulaceae
Bearing sweetly scented flowers, this variable species is from South Africa. A white powdery coating protects the stems from sun damage and drought.

COMMON HOUSELEEK
Sempervivum tectorum
F: Crassulaceae
Originating from mountains in central Europe, houseleek is often planted on roofs and walls. This plant forms dense mats of succulent rosettes.

20 in
50 cm

SAUCER PLANT
Aeonium tabuliforme
F: Crassulaceae
This native of hillsides and coastal cliffs on Tenerife, Canary Islands, forms a flat succulent rosette. After flowering the plant dies.

24 in / 60 cm

20 in
50 cm

ROSEROOT
Sedum rosea
F: Crassulaceae
Inhabiting mountain rocks and coastal cliffs, roseroot is a fleshy species found in the Arctic and alpine regions in Europe, North America, and Asia.

16 in
40 cm

ORPINE
Sedum telephium
F: Crassulaceae
Rocky terrain, woods, and hedgebanks are the habitats of orpine, a species native to much of Europe, temperate Asia, and North America.

24 in
60 cm

16 in
40 cm

FLAMING KATY
Kalanchoe blossfeldiana
F: Crassulaceae
Arid areas of Madagascar are home to this bushy species with glossy succulent leaves and brightly colored flowers.

6½ ft / 2 m

BLACK CURRANT
Ribes nigrum
F: Grossulariaceae
This species grows in damp woods in much of Europe and central Asia. Black currant is cultivated for its flavorful fruit.

6½ ft
2 m

BUFFALO CURRANT
Ribes odoratum
F: Grossulariaceae
Scented flowers and thornless stems characterize buffalo currant, an inhabitant of rocky and sandy areas in central USA.

3¼ ft / 1 m

WESTERN WATER MILFOIL
Myriophyllum hippuroides
F: Haloragaceae
This aquatic species has finely divided leaves. It is native to freshwater habitats in western North America.

PARROTIOPSIS
Parrotiopsis jacquemontiana
F: Hamamelidaceae
Instead of petals, the flowers of this forest species from the western Himalayas have white bracts, or modified leaves.

7 ft/2 m

40 ft
12 m

CHINESE SWEETGUM
Liquidambar formosana
F: Hamamelidaceae
A deciduous tree of damp woodland in China and Taiwan, this species is noted for its brightly colored autumn foliage.

BUDS AND FLOWERS

LEAVES CHANGING COLOR

VIRGINIAN WITCH HAZEL
Hamamelis virginiana
F: Hamamelidaceae
The flowers are fragrant and the leaves turn yellow in autumn. It inhabits woodland in eastern North America.

13 ft/4 m

3 ft/1 m

CHINESE ASTILBE
Astilbe chinensis var. *taquetii*
F: Saxifragaceae
With distinctive plume-like clusters of flowers, this moisture-loving plant grows in damp woodland and by streams in China, Korea, and Siberia.

50 ft/15 m

PERSIAN IRONWOOD
Parrotia persica
F: Hamamelidaceae
Native to forest in the Caucasus region and northern Iran, Persian ironwood is a winter-flowering deciduous tree with brilliantly colored autumn leaves.

MOTHER OF THOUSANDS
Saxifraga stolonifera
F: Saxifragaceae
Native to shady habitats in China and Japan, this perennial produces stolons, stemlike clusters that can root to form new plants.

12 in
30 cm

YELLOW SAXIFRAGE
Saxifraga aizoides
F: Saxifragaceae
Streamsides and wet stony areas of mountains are home to this mat-forming species of Europe, North America, and western Asia.

8 in
20 cm

ALUMROOT
Heuchera americana
F: Saxifragaceae
Inhabiting rocky woodland in North America, alumroot has glossy leaves which are mottled when young.

24 in/60 cm

flowers form in a flattish topped cluster

ELEPHANT'S EARS
Bergenia strachey
F: Saxifragaceae
An inhabitant of damp woodland and meadows in the western Himalayas and Afghanistan, elephant's ears has fragrant flowers and large glossy leaves.

large glossy leaves

6 in/15 cm

OPPOSITE-LEAVED GOLDEN-SAXIFRAGE
Chrysosplenium oppositifolium
F: Saxifragaceae
The procumbent stems of this species form extensive patches in damp shady habitats in western and central Europe.

COMMON PEONY
Paeonia officinalis
F: Paeoniaceae
A herbaceous species found in woodland, meadows, and scrub in parts of Europe, common peony is known for its showy flowers.

28 in
70 cm

12 in
30 cm

28 in/70 cm

PIGGYBACK PLANT
Tolmiea menziesii
F: Saxifragaceae
Young plantlets growing on leaf bases give piggyback plant its name. It is a hairy perennial species found in damp shady places in North America.

VITALES

This order consists of a single family, the Vitaceae or grape family. It contains 14 genera and 850 species, including the important grapevine and the ornamental Virginia creeper. Members of the Vitaceae are mainly native to the tropics or warm temperate regions. Mostly vines or lianas, they usually have swollen nodes (where leaves fork from the stem) and tendrils for climbing. Their flowers are usually held in flat-topped clusters.

GRAPEVINE
Vitis vinifera
F: Vitaceae

Humans have used grapes to make wine, food, and medicine since neolithic times. Very widespread, the grapevine is native to the Mediterranean, Europe, and Asia.

115 ft
35 m

fruit smaller than domesticated varieties

CRIMSON GLORY VINE
Vitis coignetiae
F: Vitaceae

Cultivated for its giant, dimpled leaves (12 in/30 cm across) and fall color, this deciduous climber is native to temperate Asia.

49 ft
15 m

VIRGINIA CREEPER
Parthenocissus quinquefolia
F: Vitaceae

This prolific climber from eastern and northern America clings onto smooth surfaces using the adhesive pads on its small, forked tendrils.

foliage turns red in the fall

98 ft
30 m

GERANIALES

The Geraniales has only four plant families. The *Geraniaceae* or geranium family is the largest, with 800 species within seven genera, of which the genus *Geranium* or cranesbills has 260 species. The genus *Pelargonium* has 280 species including the garden plants commonly known as geraniums. *Melianthaceae* is another family of the Geraniales; its members are trees and shrubs native to tropical and southern Africa.

8¼ ft
2.5 m

GIANT HONEYBUSH
Melianthus major
F: Melianthaceae

Nectar drips from the bronze flower spikes of this South African native. Touching the leaves causes them to give off a strong odor.

20 in
50 cm

HERB ROBERT
Geranium robertianum
F: Geraniaceae

Widespread in the Northern Hemisphere, this sprawling species has red stems and long flower stalks. It has a strong, mousy smell.

12 in
30 cm

APPLE PELARGONIUM
Pelargonium odoratissimum
F: Geraniaceae

This perennial originates from South Africa and has spreading flower stalks. It is cultivated for "oil of geranium," which has a strong scent of apple and rose.

23½ in
60 cm

MEADOW CRANESBILL
Geranium pratense
F: Geraniaceae

Preferring grasslands on chalky soil, this perennial is native to Europe and Asia. It is the main food source for the northern brown argus butterfly.

8 in
20 cm

ROCK STORKSBILL
Erodium petraeum
F: Geraniaceae

Storksbills take their name from the shape of their seeds. This Mediterranean perennial is cultivated in rock gardens.

MYRTALES

The order Myrtales is found throughout the tropics and warmer regions. Of the 14 families, the Myrtaceae (myrtle family) is the biggest with over 5,630 species. They tend to produce essential oils, such as myrtle, clove, and eucalyptus. The Lythraceae (loosestrife and pomegranate family) have petals that emerge from a floral tube (calyx) that includes petals and the stamen. Most of the Onagraceae (willowherb or evening primrose family) have four colored sepals and petals.

20 ft
6 m

CRAPE MYRTLE
Lagerstroemia indica
F: Lythraceae

Blooming for up to 120 days, this tree is native to China, Korea, and Japan. Its bark is smooth, mottled, pinkish gray, and is shed each year.

20 ft
6 m

HENNA
Lawsonia inermis
F: Lythraceae

Native to N. Africa and the Middle East, henna's leaves make a reddish-brown dye and its fragrant flowers yield essential oils.

8 in–4 ft
2.5 m

SWAMP LOOSESTRIFE
Decodon verticillatus
F: Lythraceae

Native to northeastern America, this shrub grows in swamps. It has stems with up to six sides, its leaves grow in whorls of three and it has ¾-in (1-cm) flowers.

30 in
75 cm

WATER CHESTNUT
Trapa natans
F: Lythraceae

This floating plant is from Europe and Asia. Within a nut with four hornlike barbed spines is the edible starchy seed.

23 ft
7 m

POMEGRANATE
Punica granatum
F: Lythraceae

This spiny, shrubby tree, from southwestern Asia, is widely cultivated in the Mediterranean for its pulpy fruit, containing numerous seeds.

5 ft
1.5 m

PURPLE LOOSESTRIFE
Lythrum salicaria
F: Lythraceae

Numerous purple-red, square stems grow from the woody, creeping rootstock of this perennial. Native to Europe, Asia, southeastern Australia, and northwestern Africa, it is invasive.

35 in
90 cm

CIGAR FLOWER
Cuphea ignea
F: Lythraceae

A densely branched, perennial shrub, cigar flower is a garden and house ornamental. Native to Mexico and the West Indies, its fruit is paperlike capsules.

59 ft
18 m

RANGOON CREEPER
Quisqualis indica
F: Combretaceae

This climber from tropical Asia has clusters of tubular red flowers. Its ellipsoidal fruit, each with five wings, taste of almonds.

98 ft
30 m

INDIAN ALMOND
Terminalia catappa
F: Combretaceae

Found on coasts of the Indo-Pacific oceans, this tree has horizontal branches. Its corky fruit, dispersed by water, contains an edible, almond-tasting nut.

20 ft
6 m

ROSE GRAPE
Medinilla magnifica
F: Melastomataceae

This ornamental from the Philippines is an epiphyte, growing on trees. Its leaves have the longitudinal veins characteristic of the melastomes.

16 ft
5 m

BRAZILIAN SPIDER FLOWER
Tibouchina urvilleana
F: Melastomataceae

In warm regions this Brazilian ornamental blooms for most of the year. Its velvety leaves have red edges and three to five obvious longitudinal veins.

23 in
60 cm

VIRGINIA MEADOW BEAUTY
Rhexia virginica
F: Melastomataceae

This hairy, perennial herb grows in wetlands of the eastern US. It has square stems and stalkless leaves with toothed margins.

»

» MYRTALES

stamens form bottlebrush-shaped flowers

9¾ ft
3 m

GREEN BOTTLEBRUSH
Callistemon viridiflorus
F: Myrtaceae

Resisting snow, frost, and drought, this sprawling shrub from southern Australia has leaves with sharp, pointed ends. It attracts birds and butterflies.

9¾ ft
3 m

TONGHI BOTTLEBRUSH
Callistemon subulatus
F: Myrtaceae

A spreading shrub with small woody fruit containing hundreds of seeds. It is found mainly in New South Wales and Victoria, Australia.

130 ft
40 m

RED GUM
Eucalyptus camaldulensis
F: Myrtaceae

Widespread in Australia, with smooth, pale bark and blue-green leaves, this tree has durable wood and its nectar makes good honey.

TASMANIAN SNOW GUM
Eucalyptus coccifera
F: Myrtaceae

With gray-white bark, peeling in long strips to reveal a creamy-white trunk, this Tasmanian native has rounded, unstalked, opposite leaves.

82 ft
25 m

elliptical leaves smell of peppermint

120 ft
36 m

CIDER GUM
Eucalyptus gunnii
F: Myrtaceae

This hardy Tasmanian tree forms juvenile leaves that are round and silvery, maturing to scythe-shaped and blue-gray. It has red-brown peeling bark.

16 ft
5 m

39 ft
12 m

ALLSPICE
Pimenta dioica
F: Myrtaceae

From the Caribbean, southern Mexico, and Central America, this unisexual tree has small white flowers that form brown berrylike pitted fruit. Unripe fruit is dried and ground to make "allspice."

39 ft
12 m

URN-FRUITED GUM
Eucalyptus urnigera
F: Myrtaceae

This tree from southeast Tasmania has urn-shaped fruit, blue-gray juvenile leaves, and white flowers in clusters of three with numerous stamens.

9¾ ft
3 m

SCARLET KUNZEA
Kunzea baxteri
F: Myrtaceae

Unlike *Callistemon* bottlebrushes these woody shrubs from the south coast of West Australia lose their five sepals and petals, leaving a one-celled fruit.

COMMON MYRTLE
Myrtus communis
F: Myrtaceae

The aromatic leaf of myrtle yields essential oils. Native to the Mediterranean, myrtle has fragrant flowers and produces blue-black berries.

66 ft
20 m

49 ft
15 m

CHILEAN MYRTLE
Luma apiculata
F: Myrtaceae

This slow-growing tree has a contorted trunk and smooth gray-orange peeling bark. Its fruit is a black berry.

82 ft
25 m

CAJUPUT
Melaleuca cajuputi
F: Myrtaceae

Native to the islands of Indonesia, this tree has aromatic leaves that contain an emerald-colored medicinal oil.

POHUTAKAWA
Metrosideros excelsa
F: Myrtaceae

This tree produces red flowers in December. It is native to North Island, New Zealand, clinging to rocky cliffs with its long, hanging roots.

39 ft
12 m

CLOVE
Syzygium aromaticum
F: Myrtaceae

The dried flower buds of this native of Indonesia and the Philippines are used as a spice. The flowers are cream-colored with red stamens and purple single-seeded berries.

26 ft
8 m

EVERGREEN LEAVES

EDIBLE FRUIT

GUAVA
Psidium guajava
F: Myrtaceae

This tree from southern Mexico has flaky, coppery bark. The fruit has a sweet, musky smell when ripe, and contains numerous hard, yellow seeds.

3¼ ft
1 m

GODETIA
Clarkia amoena
F: Onagraceae

This annual is native to coastal hills of western North America. Cultivated in gardens, its flower has four broad petals and forms a dry capsule, containing numerous seeds.

5 ft
1.5 m

FUCHSIA FULGENS
F: Onagraceae

Clinging to rocks as a lithophyte or trees as an epiphyte with its long, tuberous roots, this deciduous perennial is native to the mountains of Mexico.

9¾ ft
3 m

HARDY FUCHSIA
Fuchsia magellanica
F: Onagraceae

This widespread, deciduous, ornamental perennial originates from Chile, where it usually has its roots in water. It produces black berries.

5 ft
1.5 m

ROSEBAY WILLOWHERB
Chamerion angustifolium
F: Onagraceae

This herbaceous perennial, widespread throughout the temperate northern hemisphere, spreads rapidly using horizontal stems. Its fruit capsule splits four ways to release seeds.

large, purple-pink flower

28 in
70 cm

SHOWY EVENING PRIMROSE
Oenothera speciosa
F: Onagraceae

This herbaceous, smooth-stemmed perennial is from the southeastern US and Mexico. Its white flowers become pink with age and close in full sun.

20 in
50 cm

5 ft
1.5 m

EVENING PRIMROSE
Oenothera biennis
F: Onagraceae

This biennial from eastern North America has bluish green leaves in a basal rosette and erect stems bearing flowers that open at night. The seed oil has medicinal properties.

stigma has four white lobes

6½ ft
2 m

GREAT WILLOW HERB
Epilobium hirsutum
F: Onagraceae

This very hairy perennial forms extensive patches with its horizontal stems. It is native to most of North America, Europe, and parts of Asia.

28 in
70 cm

ENCHANTER'S NIGHTSHADE
Circaea lutetiana
F: Onagraceae

This woodland plant is distributed through the temperate northern hemisphere. Flowers of two sepals and two notched petals form small, round, hairy fruit.

characteristic four petals

3¼ ft
1 m

SEEDBOX
Ludwigia alternifolia
F: Onagraceae

Preferring to grow in swamps, this plant is native to Missouri. It has box-shaped seedpods borne on angled stems.

CELASTRALES

This is a diverse order with few visibly distinguishing characteristics, apart from small flowers and an obvious nectar disc. The Celastrales contains about 1,300 species, within 100 genera. The divisions within the order are probably still not completely resolved but 93 of the genera are in the family Celastraceae (staff vine or bittersweet) of vines or shrubby trees.

SPINDLE TREE
Euonymus europaeus
F: Celastraceae

Native to Europe, the wood of this tree was used to make spindles—spikes used to spin thread. Its fruit ripens to red and splits into four to reveal orange-coated, poisonous seeds.

20 ft
6 m

nectar disc

elliptical leaves

GRASS OF PARNASSUS
Parnassia palustris
F: Parnassiaceae

This rosette plant grows in bogs in the northern temperate zone. Each flower is borne on a stem, clasped by a stalkless leaf.

12 in
30 cm

CUCURBITALES

Including trees, shrubs, herbs, and climbers, the Cucurbitales are mainly found in tropical areas. There are about 2,300 species contained within seven families. The Begonia family has 1,400 species, 130 of which are horticultural plants, and the Gourd family has 825 species, including some important food species such as squash and pumpkins. Both these families have monoecious (has both male and female flowers) species.

WHITE BRYONY
Bryonia dioica
F: Cucurbitaceae
Common in central and southern Europe in hedgerows on calcium carbonate-rich soils, this is a vigorous climber with an enormous, tuberous root.

CUCUMBER
Cucumis sativus
F: Cucurbitaceae
The cucumber has tubular yellow flowers, and originated in tropical Asia. Cultivated for 3,000 years, there are many varieties including the gherkin.

SQUASH
Cucurbita pepo
F: Cucurbitaceae
With five-sided prickly stems and large yellow-orange flowers, pumpkins, marrows, and zucchini are all varieties of *Cucurbita pepo* from Central America.

SMOOTH LOOFAH
Luffa cylindrica
F: Cucurbitaceae
This climbing, annual vine is native to South America. The fruit grows to 24 in (60 cm) long and contains edible, white flesh, and a fibrous structure.

CALABASH
Lagenaria siceraria
F: Cucurbitaceae
This vine produces whitish crinkly flowers. Its edible, hard-shelled fruit floats in the sea for months and is used as a container.

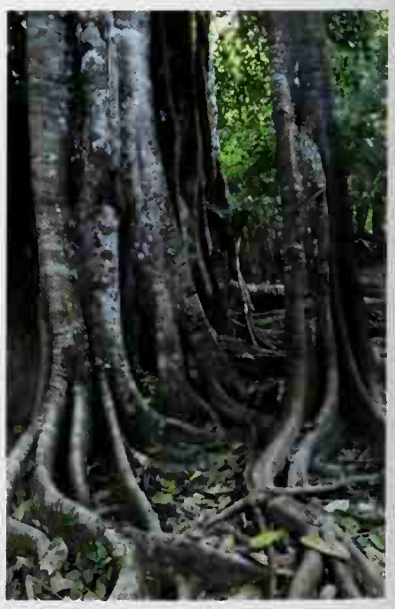
SQUIRTING CUCUMBER
Ecballium elaterium
F: Cucurbitaceae
This Mediterranean plant has fruits that fill up with a thick, sticky liquid as they ripen and explode their contents as far as 20 ft (6 m).

WATERMELON
Citrullus lanatus
F: Cucurbitaceae
With yellow-green flowers, this annual, prostrate vine originated in South Africa and its fruit is cultivated throughout warmer climates.

BEGONIA LISTADA
F: Begoniaceae
Native to Brazil, this species sprawls, has thick, velvety leaves with red undersides, and white pinkish flowers. It was first described in 1981.

BALSAM PEAR
Momordica charantia
F: Cucurbitaceae
Also known as bitter gourd, this tropical vine produces bitter-tasting fruit that splits three ways to release red-brown seeds encased in scarlet arils, or coats.

16 ft
5 m



TETRAMELES NUDIFLORA
F: Datiscaceae
This Indo-Malayan tree has a thick, heavily-fluted, cylindrical trunk. There are small, cream male and female flowers on different trees that form seed capsules.

FABALES

Found all over the world, except for Antarctica, the Fabales have compound leaves with tiny outgrowths (stipules) at the base and seed pods that open when mature. Called legumes, these plants have nodules swellings that contain bacteria on their roots that help them fix nitrogen from the air into soil. The Fabaceae, the largest of the four families, includes plants like the pea, overleaf, with flowers that have a large upper petal with adjacent smaller petals.

MIMOSA
Acacia dealbata
F: Fabaceae

This tree has fragrant flowers and blue-green bark, aging to black. Preferring mountain gullies, it is native to Southwest Australia.

FLAT WATTLE
Acacia glaucoptera
F: Fabaceae

This spreading, erect shrub of Southwest Australia has narrow, black, twisted seed pods and yellow, globular flowers.

KIDNEY VETCH
Anthyllis vulneraria
F: Fabaceae

A climber found in dry, often chalky, grasslands, with silky haired, spreading stems. The cream to red flowers are in clusters with a ruff of thick downy sepals.

PEANUT
Arachis hypogaea
F: Fabaceae

Native to Central and South America, this legume has yellow, reddish veined pealike flowers. Its seed pod matures in the ground, producing peanuts.

SAINFOIN
Onobrychis viciifolia
F: Fabaceae

This fodder crop from Eurasia has green, oval, pinnate leaves with 6–14 pairs of leaflets. Densely packed pink flowers appear on a main stem.

TAMARIND
Tamarindus indica
F: Fabaceae

This evergreen tree with drooping branches from East Africa and Asia has yellow-orange flowers on stems and edible pulp inside the seed pod.

GOLDEN SHOWER TREE
Cassia fistula
F: Fabaceae

This slender tree from southeast Asia has pendulous pealike flowers and pinnate leaves with three to eight pairs of leaflets. It contains poisonous seeds.

WEST INDIAN LOCUST TREE
Hymenaea courbaril
F: Fabaceae

This hardwood tree has a straight, thick trunk and stems of white purplish flowers with large petals and long stamens. Orange gum oozes from the trunk.

SENSITIVE PLANT
Mimosa pudica
F: Fabaceae

This prickly, Brazilian shrub's leaves close when touched. Its flowerheads (¾ in/ 1 cm) usually have pink flowers and long pink-purple stamens.

35 in
90 cm

3¼ ft
1 m

WILD LICORICE
Astragalus glycyphyllos
F: Fabaceae

With similar leaves to true licorice, this perennial herb from northwest Europe can be used as tea and has a curved pod.

BLUE FALSE INDIGO
Baptisia australis
F: Fabaceae

The sap of this herbaceous perennial, native to woods and streamsides in the eastern US, turns purple when exposed to air, and is used as an indigo dye substitute.

OBLONG, GLOSSY LEAVES

SPONGY SEED

130 ft/40 m

BLACK BEAN TREE
Castanospermum australe
F: Fabaceae

This lumber tree, with orange-red flowers carried on stems, has large, woody seedpods. The seeds are poisonous.

EVERGREEN LEAVES

33 ft
10 m

SEEDS

PULPY PODS

CAROB TREE
Ceratonia siliqua
F: Fabaceae

This Mediterranean tree has a thick trunk, dense foliage, and small, dull-green flowers. Pulp from the seedpods is a chocolate substitute.

JUDAS TREE
Cercis siliquastrum
F: Fabaceae

This deciduous, ornamental and lumber tree from the eastern Mediterranean flowers profusely in the spring, then later develops flat 4-in (10-cm) seedpods.

33 ft
10 m

young seedpod

20 in
50 cm

CHICK PEA
Cicer arietinum
F: Fabaceae

One of the earliest cultivated vegetables from the Middle East, its seedpod contains one to three seeds, which can be cooked to make hummus.

5 ft
1.5 m

GORSE
Ulex parviflorus
F: Fabaceae

This dense, spiny, perennial shrub from the Mediterranean has yellow leaves and short, brown-black pods. Fire and brush clearance aid seed germination.

5 ft/1.5 m

GOAT'S-RUE
Galega officinalis
F: Fabaceae

Naturalized in temperate areas, this perennial, with long, cylindrical red-brown seedpods, is believed by some to improve lactation and reduce fevers and diabetes.

9¾ ft
3 m

MOUNT ETNA BROOM
Genista aetnensis
F: Fabaceae

Native to Sicily, around the slopes of Mount Etna, and Sardinia, this small tree has few leaves; the green shoots responsible for photosynthesis.

PURPLISH PINK FLOWER

POD CONTAINS 10–15 SEEDS

33 ft/10 m

BROAD-LEAVED EVERLASTING PEA
Lathyrus latifolius
F: Fabaceae

Distributed through central Europe, this vigorous, climbing perennial has winged stems and its flowers are white or shades of pink. Its seeds (peas) form in long pods.

DORYCNIUM
Dorycnium hirsutum
F: Fabaceae

This Mediterranean perennial forms gray-green shrubby mounds. Its red-brown cylindrical pods can be mistaken for small berries.

20 in
50 cm

COMMON BIRD'S FOOT TREFOIL
Lotus corniculatus
F: Fabaceae

Found in pastureland in Europe, Asia, and Africa, it has yellow flowers and five lobed leaves, three of which sit above the others. Its seedpods resemble a bird's foot.

12 in
30 cm

5 ft/1.5 m

COMMON VETCH
Vicia sativa
F: Fabaceae

This scrambling, widespread annual is native to Europe and the Mediterranean. An animal feed crop, its flowers are normally paired and its tendrils can be branched.

3¼ ft
1 m

CROWN VETCH
Coronilla varia
F: Fabaceae

This rapidly spreading perennial of central southern Europe has thick leaves and deep roots, good for binding soil and controlling erosion.

6½ ft
2 m

BROOM
Cytisus scoparius
F: Fabaceae

Found in northwest Europe's heaths, this shrub has strongly scented flowers and many slender, ridged, and angled branches traditionally used for brooms.

PEA FLOWERS

1.2 in
30 cm

TWISTED SEEDPODS

HORSESHOE VETCH
Hippocrepis comosa
F: Fabaceae

This prostrate perennial, native to England, Holland, and Germany, is an important food plant for blue butterfly caterpillars. The flowers develop into a clawlike seedpods.

ALFALFA
Medicago sativa
F: Fabaceae

This deeply rooting perennial grows on chalk grassland throughout the US, southwest Asia, and Europe. It is a useful animal-feed crop and has medicinal properties.

32 in
80 cm

20 in
50 cm

RED CLOVER
Trifolium pratense
F: Fabaceae

A food crop for grazing animals, this perennial has long-stalked basal (primitive) leaves, and an oblong fruit pod hidden within its flower head.

4 ft
1.2 m

flowers densely packed

COMPOUND LEAVES

BLUE-VIOLET FLOWERS

3¼ ft
1 m

ROOT

LICORICE
Glycyrrhiza glabra
F: Fabaceae

This feathery perennial has smooth, small, oblong pods and deep roots. Extract from the roots is 50 times sweeter than sugar and is medicinal.

strong stem

12 ft
3.7 m

SCARLET RUNNER BEAN
Phaseolus coccineus
F: Fabaceae

Native to Central American mountains, the shoot of this perennial twists clockwise around its support. Its seeds (beans) are variously colored.

25 ft
7.5 m

COMMON LABURNUM
Laburnum anagyroides
F: Fabaceae

This very poisonous tree is native to central and southern Europe. Clusters of brown hairy pods (3 in (7.5 cm)) contain toxic black seeds.

narrow leaflet

82 ft / 25 m

16 in
40 cm

BLACK LOCUST
Robinia pseudoacacia
F: Fabaceae

This deciduous, vigorous tree has poisonous roots and bark, producing suckers and flat brown seedpods. It originates from the southeast US.

NICEAN MILKWORT
Polygala nicaeensis
F: Polygalaceae

This Mediterranean perennial species has flowers with two sepals and three joined petals, one of which is fringed, and a small capsule as a fruit.

GARDEN LUPIN
Lupinus polyphyllus
F: Fabaceae

Originating from western North America and naturalized throughout Europe, this popular ornamental has hairy, black pods and undersides of leaves. Its flowers are fragrant.

FAGALES

Some of the world's best-known trees belong to this order. Fagales contains the beech genus, *Fagus*, the Betulaceae or birch family, and the Juglandaceae or walnut family, as well as five other families. These trees dominate the woodlands in which they grow. They have simple leaves and small, unisexual flowers (either male or female) that are pollinated by wind.

65 ft
20 m

fruit and seed develop from catkins

FOREST OAK
Casuarina torulosa
F: Casuarinaceae

The timber of this Australian tree is prized by wood-turners. Its pendulous branches carry long, needlelike leaves and seeds in small, warty cones.

80 ft
25 m

JAPANESE HOP HORNBEAM
Ostrya japonica
F: Betulaceae

This species from eastern Asia has gray-brown scaly bark. Its seeds, or nuts, are enclosed in husks, like hops, and hang in long clusters.

80 ft
25 m

bracts

EUROPEAN HORNBEAM
Carpinus betulus
F: Betulaceae

Frequenting fencerows, this European native has small, green, male and female catkin flowers that develop into nuts with three-lobed bracts.

male catkins

leaf bud

100 ft
30 m

100 ft
30 m

RED ALDER
Alnus rubra
F: Betulaceae

A native of western North America, this tree prefers damp slopes and margins of watercourses. It has pale gray bark that becomes red when bruised or scraped.

EUROPEAN HAZELNUT
Corylus avellana
F: Betulaceae

This European shrubby tree is harvested for its edible nuts. The distinctive male catkins appear very early in spring.

30 ft
10 m

female flowers

catkins, or cylindrical clusters of male flowers

100 ft
30 m

LEAF SPRIG WITH UNRIPE FRUIT

ENGLISH WALNUT
Juglans regia
F: Juglandaceae

A species from the mountains of central Asia, the walnut tree is valued for fruit and lumber. It has smooth gray bark and male catkins up to 10 cm (4 in) long.

RIPE WALNUT

RIPE PECAN

PINNATE LEAVES

130 ft
40 m

PECAN
Carya illinoensis
F: Juglandaceae

The pecan is native to North America and cultivated for its edible nuts. The nuts are enclosed in a husk that splits four ways when ripe.

50 ft
15 m

PLATYCARYA STROBILACEA
F: Juglandaceae

Native to eastern Asia, this tree has clusters of erect male catkins and a fruit, like a conifer cone, with winged seeds.

100 ft
30 m

toothed leaves

spiny bur encases nuts

EUROPEAN CHESTNUT
Castanea sativa
F: Fagaceae

Cultivated for 3,000 years for its nuts, this tree is from southeastern Europe and western Asia. Its catkins contain male flowers in the upper part and female flowers below.

100 ft
30 m

BUTTERNUT
Juglans cinerea
F: Juglandaceae

This deciduous tree, native to North America, has yellow-green catkins. Small bunches of egg-shaped nuts contain sweet seeds.

SILVER BIRCH
Betula ermanii
F: Betulaceae

This tree has peeling, whitish bark and a weeping habit. A species from Europe and northern Asia, it prefers light, sandy soils.

100 ft
30 m

AMERICAN BEECH
Fagus grandifolia
F: Fagaceae

This broadly spreading tree from North America has gray-brown bark. It has glossy deciduous leaves and paired fruits (beechnuts) in husks.

deciduous leaves

SCALY ACORN CUP

CATKIN SPRIG

115 ft
35 m

ENGLISH OAK
Quercus robur
F: Fagaceae

Long-lived, with valuable lumber, this tree is common in western Europe, especially Britain. It bears male flowers, in the form of catkins, and long-stalked acorns.

SCARLET OAK
Quercus coccinea
F: Fagaceae

The leaves of this North American tree turn a characteristic deep red in fall. This oak bears long, yellow-green male catkin flowers and its acorns have a glossy cup.

80 ft
25 m

AUTUMN LEAF

SPRING COLOR

30 ft
10 m

KERMES OAK
Quercus coccifera
F: Fagaceae

An evergreen, shrubby tree from the Mediterranean area, this species has hollylike leaves that are bronze when young, and yellow-brown male catkins.

nut clusters form in leaf axils

50 ft
15 m

JAPANESE STONE OAK
Lithocarpus edulis
F: Fagaceae

This Japanese evergreen tree has upright creamy-white catkins, which have female flowers at the base and males above. The edible acorns ripen over two years.

80 ft
25 m

RAULI
Nothofagus nervosa
F: Nothofagaceae

A timber tree, rauli is native to Argentina and Chile. The young leaves are bronze. Greenish female flowers grow in clusters and form bristly husks enclosing small nuts.

6½ ft
2 m

SWEET GALE
Myrica gale
F: Myricaceae

This sweet-smelling shrub, traditionally used as an insect repellent, grows in peat bogs in northern temperate zones. It has either male or female reddish catkins.

MALPIGHIALES

One of the largest and most diverse orders of mostly tropical plants, Malpighiales contains about 16,000 species. The plants in this order are genetically similar but physically different. Well-known families are the euphorbias, which have unisexual flowers (either male or female), and others that include species such as the passionflower, willow, and viola. Many of the families in this order are hardly known outside their native regions.

POISONOUS FRUIT

32 in
80 cm

PAIRED LEAVES

TUTSAN
Hypericum androsaemum
F: Clusiaceae

This small shrub from western Europe has reddish, two-ridged stems. Its aromatic leaves have medicinal uses, but its berries are poisonous.

32 in
80 cm

PERFORATE ST. JOHN'S-WORT
Hypericum perforatum
F: Clusiaceae

This European perennial is a common plant of banks, fields, and roadsides. It has round stems with ridges on either side, leaves with translucent dots, and many seeded capsules.

100 ft
30 m

CEYLON IRONWOOD
Mesua ferrea
F: Clusiaceae

This tree yields heavy lumber, hence its common name. It has large flowers with four white petals and bright red young leaves.

»

» MALPIGHIALES

CANDLE-NUT TREE
Aleurites moluccana
F: Euphorbiaceae

Oil from the nuts of this tropical tree was used to make candles. It has stems of small, creamy flowers and its variable leaves are gray-green when young.

CASSAVA
Manihot esculenta
F: Euphorbiaceae

Originating from South America, its tuberous roots are used to make tapioca. It has small flower clusters that grow on secondary branches.

CROWN OF THORNS
Euphorbia milii
F: Euphorbiaceae

This semisucculent, climbing shrub from Madagascar has very spiny stems. Its leaves are mainly on the new shoots.

LIVING BASEBALL
Euphorbia obesa
F: Euphorbiaceae

Rare in the wild, this ball-shaped succulent originates from the Great Karoo, South Africa. Its tiny flowers grow from "eyes" at its top.

CASTOR OIL PLANT
Ricinus communis
F: Euphorbiaceae

Castor oil is extracted from the poisonous seeds of this species from tropical Africa. With upright flower heads, the upper female flowers have red stigmas and lower males yellow anthers.

JATROPHA GOSSYPIFOLIA
F: Euphorbiaceae

This invasive, toxic plant, banned in Australia, is native to tropical America. It has sticky leaves, watery sap, and flowers with purple bracts.

LARGE MEDITERRANEAN SPURGE
Euphorbia characias
F: Euphorbiaceae

This ornamental, Mediterranean perennial has upright, purplish woolly stems, hare and smooth at the base. The fruit, or seed capsule, is hairy and berrylike.

CROTON
Croton tiglium
F: Euphorbiaceae

Used in Chinese medicine, this tree from Southeast Asia has malodorous leaves and s male and female flowers that form seed capsules.

SAUSAGE SPURGE
Monadenium guentheri
F: Euphorbiaceae

This evergreen succulent from tropical Africa has white flower bracts with purple markings. It has fat sickle-shaped leaves mainly on young growth.

RUBBER TREE
Hevea brasiliensis
F: Euphorbiaceae

A native of Brazil, this tree is famous for the milky sap (latex) under its bark used for rubber. It has leaves with three leaflets and pungent yellow flowers.

DOG'S MERCURY
Mercurialis perennis
F: Euphorbiaceae

This downy perennial has a single upright stem. Plants are either male or female and produce tiny green flowers on long thin stalks.

PETTY SPURGE
Euphorbia peplus
F: Euphorbiaceae

This poisonous, weedy annual, native to Europe, North Africa, and west Asia, has dividing stems and flower stalks with three branches.

PERENNIAL FLAX
Linum perenne
F: Linaceae

This slender, often spreading perennial is native to Europe, especially the Alps and Britain. Its flowers form buds at intervals at the top of the stem.

COCA
Erythroxylum coca
F: Erythroxylaceae

The leaves of this evergreen shrub from northwestern South America yield cocaine. It has gray bark and clusters of small yellowish white flowers.

BLUE PASSION FLOWER
Passiflora caerulea
F: Passilloraceae

This ornamental South American vine has scented flowers associated with Christian symholism. Flowers have five sepals and petals, five stamens, and three purple stigmas.

33 ft
10 m

AYAHUASCA
Banisteriopsis caapi
F: Malpighiaceae

This woody vine, native to the Amazon, is traditionally used to make a sacred, medicinal drink. It produces stalks of pink flowers and winged seedpods.

80 ft
25 m

RED MANGROVE
Rhizophora mangle
F: Rhizophoraceae

Found throughout the tropics, especially in swampy salt marshes, the red mangrove has prop roots and its seeds germinate before leaving their parent tree.

70 ft
21 m

IDESIA
Idesia polycarpa
F: Salicaceae

A mountain tree from east Asia, this has smooth gray bark. Small yellow-green, fragrant flowers and purple-red berries form.

24 in
60 cm

RAFFLESIA
Rafflesia arnoldii
F: Rafflesiaceae

Rafflesia is a parasite on southeast Asian rain forest vines. Its 3¼ft (1m) foul smelling flowers are the world's largest. The smell attracts flies.

80 ft
25 m

WHITE WILLOW
Salix alba
F: Salicaceae

This waterside tree is native to Europe and Asia. Trees have either male or female catkins, never both. The bark is a source of salicin, the active ingredient of aspirin.

40 ft
12 m

PUSSY WILLOW
Salix caprea
F: Salicaceae

This shrubby tree, native to Europe and Asia, has hairy, oval, toothed, alternate leaves. Female catkins form capsules, releasing cottony seeds.

80 ft
25 m

ASPEN
Populus tremula
F: Salicaceae

Native to Europe and Asia, the gray bark of young trees has diamond-shaped scars. Flattened stalks cause the leaves of aspen to quiver.

50 ft
15 m

flowers are up to 5 in (12 cm) across

GIANT GRANADILLA
Passiflora quadrangularis
F: Passifloraceae

This passion flower is a perennial native of South America. It bears huge, oblong fruit and has four-sided stems.

fragrant flowers may be white, red, or purple

100 ft
30 m

WHITE POPLAR
Populus alba
F: Salicaceae

This deciduous tree, native to cenral Europe and central Asia, tolerates water and salt. It is unisexual—most trees are female. Catkins form capsules that release fluffy seeds.

33 ft
10 m

AZARA MICROPHYLLA
F: Salicaceae

This evergreen tree from Argentina and Chile has small, vanilla-scented flowers with yellow stamens. Each leaf has a circular growth (stipule) at the base.

12 in–30 cm

WILD PANSY
Viola tricolor
F: Violaceae

This sprawling, short-lived perennial is native to Europe, growing in grassy habitats with neutral to acid soils. Used in herbal remedies, it is also known as heart's ease.

4 ft–4.2 m

SHRUB VIOLET
Hybanthus floribundus
F: Violaceae

This Australian woody perennial accumulates nickel. Shrub violet has bluish petals with a yellow patch and small, dark green oval leaves.

OXALIDALES

This order contains about 2,300 species, grouped within six families. Of these, the Cephalotaceae contains only one species – the carnivorous albany pitcher plant. The Cunoniaceae are woody plants that produce woody fruit capsules containing small seeds. The wood sorrel family (Oxalidaceae), is the largest with 560 species within eight genera. They are characterized by divided leaves that exhibit or open out by day and then close up at night.

ALBANY PITCHER PLANT
Cephalotus follicularis
F: Cephalotaceae

This carnivorous plant is native to the coast of southwest Australia. It has basal, oval leaves, and a liquid-filled pitcher that traps prey but it is not a member of the pitcher family (see p.192).

8 in
20 cm

flowers have five petals

13 ft
4 m

14 in
35 cm

PINK SORREL
Oxalis articulata
F: Oxalidaceae

Growing from a swollen rhizome, or root stalk, this plant from South America forms leafy mounds topped with clusters of flowers. These produce seed capsules that explode.

FLOWER CLUSTER

LEAFLET CLUSTER

CHRISTMAS BUSH
Ceratopetalum gummiferum
F: Cunoniaceae

From coastal eastern Australia, this shrub produces insignificant white flowers in spring. The pink and red sepals enlarge in winter, enclosing the fruit.

40 ft
12 m

BLACK WATTLE
Callicoma serratifolia
F: Cunoniaceae

The wood of this shrubby tree from the coast of New South Wales, Australia, was used by early settlers to make wattle-and-daub shelters. Its young foliage is bronze.

RIPE FRUIT

FLOWER SPRIG

STAR FRUIT
Averrhoa carambola
F: Oxalidaceae

This bushy tree is native to Southeast Asia is widely cultivated for its edible star-shaped fruit. It flowers four times a year.

50 ft / 15 m

ROSALES

This order of plants contains nine families, among them the Rosaceae (rose family), Cannabaceae (hemp family), Moraceae (mulberry family), Rhamnaceae (buckthorn family), Ulmaceae (elm family), and Urticaceae (nettle family). Members of the Rosales are often grown for fruit or other products. Plants in this order tend to have five sepals and numerous stamens. Mostly insect-pollinated, they are often thorny or hairy.

oil-rich berries

33 ft
10 m

SEA BUCKTHORN
Hippophae rhamnoides
F: Elaeagnaceae

Widespread through Asia and Europe, this tree bears yellow flowers before the leaves. The small, bright-orange berries are rich in vitamin C.

OLEASTER
Elaeagnus angustifolia
F: Elaeagnaceae

Native to west Asia, this spreading, deciduous tree has spiny shoots, covered in silver scales. Its egg-shaped, yellow-red fruit is edible.

HEMP
Cannabis sativa
F: Cannabaceae

Originating from central and west Asia, this perennial is a source of cannabis from its leaves, fiber for making rope, and oil is extracted from its seeds.

HOP
Humulus lupulus
F: Cannabaceae

This climbing perennial is widespread throughout the temperate Northern Hemisphere. The conelike female flower or hop is used to flavor and preserve beer.

JACKFRUIT
Artocarpus heterophyllus
F: Moraceae

From lowland Southeast Asia, this tree yields the largest tree-borne fruit, weighing up to 66lb (30kg) and 36in (90cm) long when ripe.

COMMON FIG
Ficus carica
F: Moraceae

This fig is native to southwest Asia and the eastern Mediterranean. As with all figs, flowers are inside a bud and pollinated by a special wasp that enters the bud.

BLACK MULBERRY
Morus nigra
F: Moraceae

This deciduous, spreading tree, widely cultivated for its rich-flavored fruit, is native to the Middle East. It has bumpy, fissured orange bark.

PAPER MULBERRY
Broussonetia papyrifera
F: Moraceae

Fine paper is made from the inner bark of this tree from Japan and Taiwan. It produces large quantities of pollen.

OSAGE ORANGE
Maclura pomifera
F: Moraceae

Native to North America, this tree is used for hedging and its roots and wood were valued by American Indians.

JUJUBE
Ziziphus jujuba
F: Rhamnaceae

This thorny, shrubby tree is widely cultivated for its fruit in China and India. The immature, smooth, oval, green pitted fruit tastes like apple.

COMMON BUCKTHORN
Rhamnus cathartica
F: Rhamnaceae

A shrubby, invasive tree that has spine-tipped shoots, tiny yellow-green flowers, and black berries. It is native to Europe, Asia, and Africa.

NEW JERSEY TEA
Ceanothus americanus
F: Rhamnaceae

This bush from the northeastern US has purple, three-lobed capsules, containing seeds. Its red roots and hairy leaves have been used to make tea.

»

» ROSALES

CHINESE PHOTINIA
Photinia serratifolia
F: Rosaceae

A plant of Chinese forests, this tree is commonly cultivated for ornamental purposes. Its dense wood is used in furniture making.

SILVERWEED
Potentilla anserina
F: Rosaceae

This silky-haired, creeping perennial grows in wasteland, pastures, and dunes in the Americas, Europe, Asia, Australia, and New Zealand.

SNOWY MESPILUS
Amelanchier lamarckii
F: Rosaceae

Frothy clusters of star-shaped flowers in spring are followed by dark red berries in summer in this showy tree from eastern North America.

WILD CHERRY
Prunus avium
F: Rosaceae

The wild ancestor of orchard cherries grows in woods and hedges in Europe, Asia, and North Africa and is naturalized in North America.

PRAIRIE CRAB APPLE
Malus ioensis
F: Rosaceae

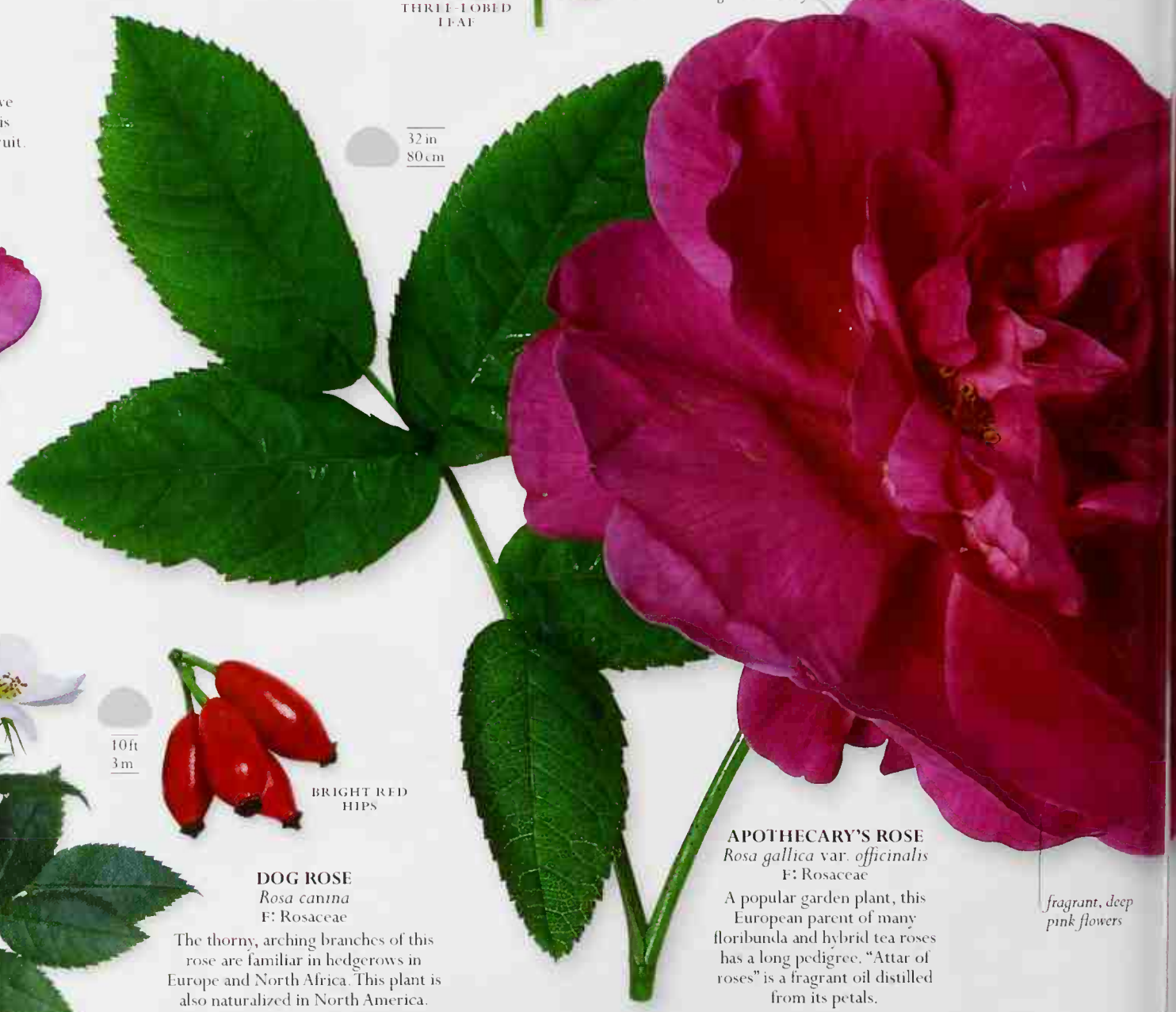
One of several crab apples native to North America, this species is cultivated for its somewhat tart fruit.

STRAWBERRY
Fragaria vesca
F: Rosaceae

The wild strawberry is a perennial in North American and European woodlands. Tiny edible fruit form from the swollen flower receptacle.

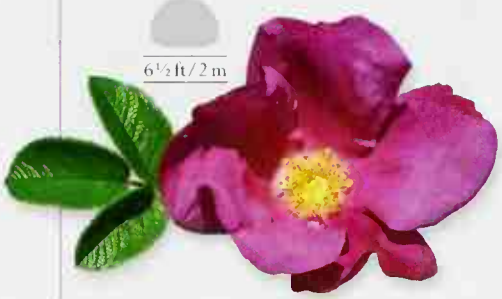
ORCHARD PLUM
Prunus domestica
F: Rosaceae

These trees originated as a cross between the cherry plum of China and the European blackthorn, but without the sharp thorns of the latter.



APOTHECARY'S ROSE
Rosa gallica var. *officinalis*
F: Rosaceae

A popular garden plant, this European parent of many floribunda and hybrid tea roses has a long pedigree. "Attar of roses" is a fragrant oil distilled from its petals.



JAPANESE ROSE
Rosa rugosa
F: Rosaceae

Tolerant of salt spray, this rose from east Asia is often planted as a hedge near the sea. It has prickly stems and pink flowers with wrinkled petals.

DOG ROSE
Rosa canina
F: Rosaceae

The thorny, arching branches of this rose are familiar in hedgerows in Europe and North Africa. This plant is also naturalized in North America.

20 in
50 cm

OAKLIKE LEAVES

EIGHT-PETALED FLOWER

MOUNTAIN AVENS
Dryas octopetala
F: Rosaceae

The flowers of this Arctic and mountain undershrub turn to follow the sun to warm their centers and attract pollinating insects.

COTONEASTER
Cotoneaster horizontalis
F: Rosaceae

This creeping Chinese shrub is commonly grown in gardens for its flowers and fruit, and occasionally escapes. The semievergreen leaves form flattened clumps.

3½ ft
1 m

10 ft / 3 m

FIRETHORN
Pyracantha rogersiana
F: Rosaceae

This thorny evergreen shrub from eastern China belongs to a genus often planted for their attractive but inedible, orange, berrylike fruit.

EDIBLE FRUIT

WHITE OR PINK FLOWERS

8 ft
2.5 m

BLACKBERRY
Rubus fruticosus
F: Rosaceae

Familiar in Europe as scrambling hedgerow bushes bearing edible fruit in fall, blackberries form a group of very closely related "microspecies."

80 ft
25 m

WILD SERVICE TREE
Sorbus terminalis
F: Rosaceae

This rare tree grows in ancient woods in Europe, Asia Minor, and North Africa. Its name is derived from the brew, *cervesia*, made from its fruit.

many small flowers

40 ft
12 m

AMERICAN MOUNTAIN ASH
Sorbus americana
F: Rosaceae

This deciduous woodland tree is native to eastern North America. Its orange berries last into winter, providing food for thrushes and jays.

20 ft / 6 m

FIVE-PETALED WHITE FLOWER

MEDLAR
Mespilus germanica
F: Rosaceae

Originally from central and southern Europe, medlar produces a hard, yellowish brown fruit. This turns soft and edible in fall, then decays.

FRUIT WITH REMAINS OF SEPALS

five-petaled white flowers

WILLOW-LEAVED PEAR
Pyrus salicifolia
F: Rosaceae

Cultivated for its pendulous, silvery foliage, not its inedible fruit, this Middle Eastern tree is endangered in the wild in Turkey.

40 ft
12 m

toothed leaflets

flower heads

SALAD BURNET
Sanguisorba minor
F: Rosaceae

Native from Europe to Iran, and introduced in North America, this perennial of lime-rich grassland has edible leaves, hence its name.

24 in
60 cm

lobed leaf

showy five-petaled flowers

red fruit with single stem

RED FRUIT, OR HAWS

COMMON HAWTHORN
Crataegus monogyna
F: Rosaceae

Occurring in woods and hedges in the wild from Europe to Afghanistan, this densely branched small tree produces massed white blossom in spring, followed by deep red fruit. It is also cultivated in gardens.

FRAGRANT BLOSSOM

15 ft
10 m

24 in
60 cm

NODDING SUMMER FLOWER

BURRLIKE FRUIT

WATER AVENS
Geum rivale
F: Rosaceae

This downy perennial grows in damp places in North America, Europe, and Asia Minor. Hooked hairs on the fruit latch onto animals for dispersal.

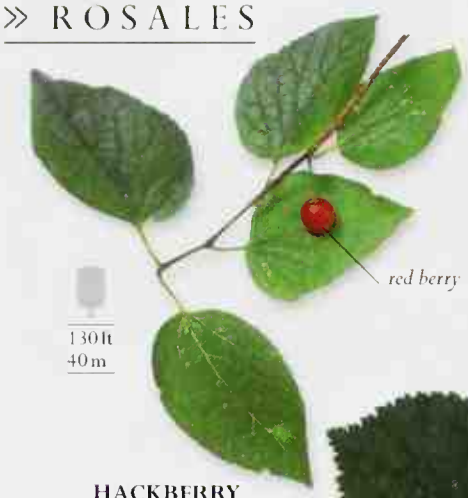
24 in
60 cm

LADY'S MANTLE
Alchemilla vulgaris
F: Rosaceae

This name encompasses several closely related grassland species from Europe, Asia, and eastern North America. Their leaves are said to resemble a trailing gown.

»

» ROSALES



HACKBERRY
Celtis occidentalis
F: Ulmaceae

Native to North America, hackberry has bright green, elmlike leaves, and red fruits eaten by many birds and mammals.

JAPANESE ZELKOVA
Zelkova serrata
F: Ulmaceae

In the USA elms killed by Dutch Elm Disease are sometimes replaced by this valuable Asian timber tree. The Japanese grow it in bonsai form.

EUROPEAN FIELD ELM
Ulmus minor
F: Ulmaceae

This tree used to be a major feature in European landscapes, but was decimated by Dutch Elm Disease.

FRIENDSHIP PLANT
Pilea involucrata
F: Urticaceae

Several *Pilea* species make valuable houseplants, including this species from Central and South America with strongly veined leaves.

STINGING NETTLE
Urtica dioica
F: Urticaceae

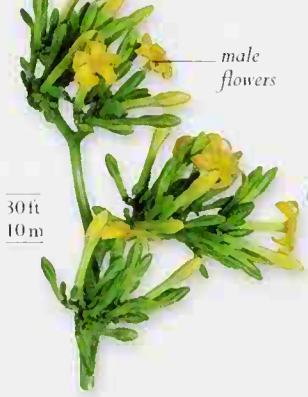
Stinging hairs discourage animals from eating nettle leaves. This species grows in disturbed ground in Europe, Asia, North Africa, and North America.

BRASSICALES

Many members of the order Brassicales have bitter or fragrant oils in their leaves, stems, or swollen roots. Although these oils evolved to deter herbivores, they make many species pleasantly edible for humans, and have culinary, perfumery, or herbal uses. The Brassicaceae, or cabbage family, is the most important group, with 3,300 species.

WILD CABBAGE
Brassica oleracea
F: Brassicaceae

Humans have grown this western European plant for millennia. Cauliflower, broccoli, and brussels sprouts are cultivated forms of the same species.



PAPAYA
Carica papaya
F: Caricaceae

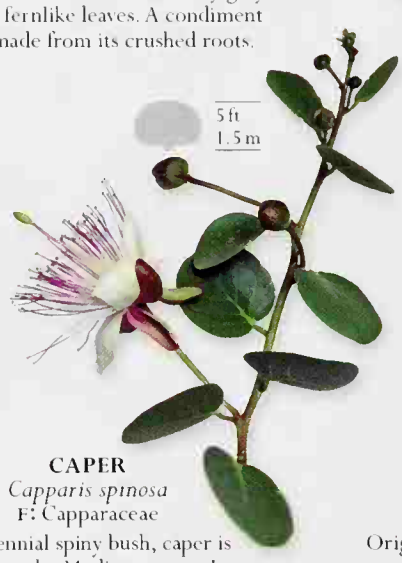
This South American treelike plant produces yellow flowers. The female flowers develop into large orange-fleshed fruits of the same name.

HORSERADISH TREE
Moringa oleifera
F: Moringaceae

This tropical Asian tree has corky gray bark and fernlike leaves. A condiment can be made from its crushed roots.

NASTURTIUM
Tropaeolum majus
F: Tropaeolaceae

A colorful annual from Central and South America, this is a popular garden plant. The flowers and leaves can be eaten in salads.



CAPER
Capparis spinosa
F: Capparaceae

A perennial spiny bush, caper is native to the Mediterranean. Its flower buds are used salted and pickled for culinary use.

COMMON MIGNONETTE
Reseda odorata
F: Resedaceae

Originally from North Africa, it is grown in gardens across southern Europe. An oil from its fragrant flowers is used in perfumery.

WALLFLOWER
Erysium cheiri
F: Brassicaceae

Probably native to cliffs and meadows in the eastern Mediterranean, this species has been cultivated throughout Europe since medieval times.

28 in
70 cm

12 in
30 cm

HONESTY SEED POD

5 ft
1.5 m

HONESTY FLOWER STEM

4 ft
1.2 m

CORALROOT BITTERCRESS
Cardamine bulbifera
F: Brassicaceae

A plant of central European beechwoods, this creeping perennial occurs from the British Isles eastward to the Caucasus and Asia Minor.

AUBRIETA
Aubrieta deltoides
F: Brassicaceae

Originating from the Aegean region, aubrieta grows readily on walls throughout the warmer parts of Europe.

HONESTY
Lunaria annua
F: Brassicaceae

Native in the wild in southeast Europe, honesty is often grown in gardens. Its seed pods are used in dried flower arrangements.

HORSERADISH
Armoracia rusticana
F: Brassicaceae

The pungent taste of the roots, which are used for horseradish sauce, evolved to deter herbivores from eating this Eurasian perennial.

FLOWER STEM

EDIBLE LEAVES

3½ ft
1 m

12 in
30 cm

16 in
40 cm

WINTERCRESS
Barbarea vulgaris
F: Brassicaceae

Native throughout Europe, wintercress was once cultivated for winter salads, and introduced for this purpose to North America, Australia, and New Zealand.

SWEET ALISON
Lobularia maritima
F: Brassicaceae

This Mediterranean annual is widely cultivated for its sweet-scented flowers. "Alison" from *alyssum* in Greek refers to its reputation for curing madness.

lobed leaves at base of stem

scented purple, red, or white flowers

FLOWERHEAD

four-petaled flower

24 in
60 cm

32 in/ 80 cm

rounded leaves are gray beneath

24 in
60 cm

DISTINCTIVE LEAF

WILD RADISH FLOWER STEM

LEAF STEM

SEA KALE
Crambe maritima
F: Brassicaceae

This cabbagelike perennial grows on gravel beaches and seacliffs around Eurasia. Its spherical fruits, which float for many days, are dispersed by the sea.

WILD RADISH
Raphanus raphanistrum
F: Brassicaceae

Also naturalized in North America, this Eurasian native may be the ancestor of garden radishes but its root is not round.

SHEPHERD'S PURSE
Capsella bursa-pastoris
F: Brassicaceae

Purse-shaped pods that split to release massed seeds have helped this species spread around the world from its native Mediterranean.

WATERCRESS
Nasturtium officinale
F: Brassicaceae

This wild Eurasian perennial grows near water and is also cultivated in tanks. Its young shoots and peppery leaves, rich in vitamin C, are used in salads.

HOARY STOCK
Matthiola incana
F: Brassicaceae

Native to coastal rocks in southwest Europe and west Asia, stock is much cultivated. "Ten Weeks Stock" is a short-lived garden variety.

MALVALES

The Malvales is a moderately large order, mainly of shrubs and trees, found with greatest variety in tropical and warm temperate regions, but extending into cooler parts. It includes two main families: the rockrose family (Cistaceae), mostly from the Northern Hemisphere; and the more widespread mallow family (Malvaceae) of herbs, shrubs, and massive trees. Among the smaller families are the Bixaceae, which has just five species.

ANNATTO
Bixa orellana
F: Bixaceae

The food dye annatto comes from the spiny fruit of this pink-flowered shrub or small tree, native to tropical America.

HAIRY ROCKROSE
Cistus incanus
F: Cistaceae

Several scientific names have been given to this widespread Mediterranean shrub, because its leaves vary greatly in hairiness and size.

COMMON ROCKROSE
Helianthemum nummularium
F: Cistaceae

Found on sunny banks throughout most of Europe, this low shrub prefers lime-rich soil. Different subspecies grow in Europe's mountains.

CALIFORNIAN FLANNELBUSH
Fremontodendron californicum
F: Malvaceae

The flowers of this spreading shrub produce showy masses in early summer. It lives high up in the granite mountains of California.

CHINESE HIBISCUS
Hibiscus rosa-sinensis
F: Malvaceae

The tropical Chinese hibiscus, or China rose, is one of several *Hibiscus* species cultivated especially for their showy blossoms.

MEZEREON
Daphne mezereum
F: Thymelaeaceae

Damp woods and shady gorges are the typical habitat of this deciduous shrub, which is found across most of Europe.

MUSK MALLOW
Malva moschata
F: Malvaceae

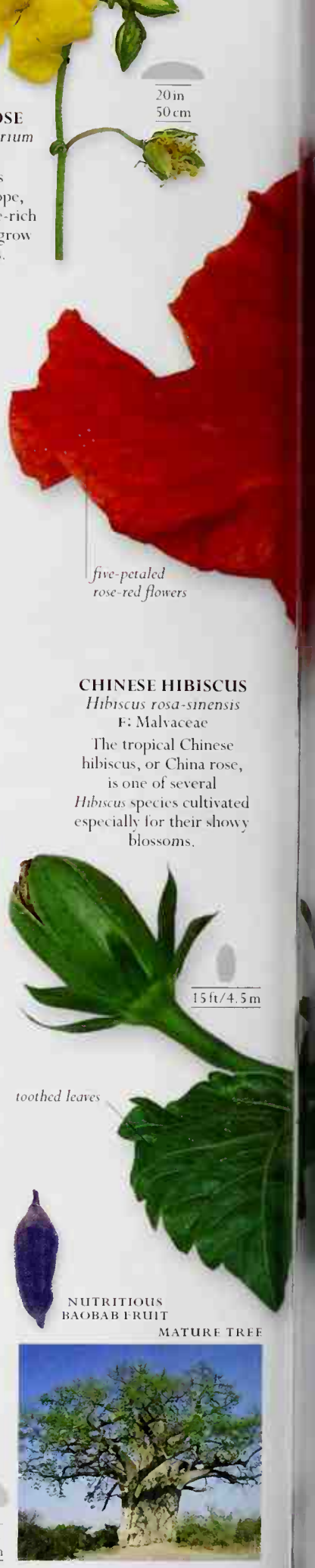
Native to North Africa and southern Europe, and a garden plant farther north, this tall perennial grows in grassy and bushy places.

COCOA
Theobroma cacao
F: Malvaceae

Originally from Brazilian rain forests, this tree is cultivated around the tropics. Cocoa comes from the seeds, known as beans, inside its fruit pods.

COLA NUT TREE
Cola nitida
F: Malvaceae

The caffeine-rich seeds (called cola nuts) from the pods of this West African tree are chewed for their stimulant effects.



BAOBAB TREE
Adansonia digitata
F: Malvaceae

This massive African tree is called an upside-down tree because, when leafless, its branches look like roots. It can live 3,000 years.

pollen is attached to filaments on central stamen tube

TRAILING ABUTILON
Abutilon megapotamicum
F: Malvaceae
Native to Argentina, Brazil, and Uruguay, this spreading shrub is also popular as a colorful ornamental in warm, sunny gardens.

6ft / 1.8m

GLOSSY LEAVES

SPINY FRUIT

130ft / 40m

DURIAN
Durio zibethinus
F: Malvaceae
The spiny fruit of this Asian rain forest tree smell like sweaty socks. This attracts animals to eat the fruit then disperse the seeds in their droppings.

120ft / 36m

6ft / 1.8m

AMERICAN LIME
Tilia americana
F: Malvaceae
This medium to large deciduous tree adds to fall colors in woodlands across northeastern America. It often grows alongside sugar maple.

FLOWER SPRIG

WILD HOLLYHOCK
Alcea pallida
F: Malvaceae
This tall evergreen perennial, a close relative of garden hollyhocks, comes from the eastern Mediterranean. It grows in rocky places and scrubland.

LEAF CLUSTERS

230ft / 70m

OPEN BOLL

5ft / 1.5m

BROWN-FILLED POD

KAPOK
Ceiba pentandra
F: Malvaceae
Massive kapok trees grow wild in West Africa, and Central and South America. Fiber from their fruit, or pods, is used as a stuffing for toys.

UPLAND COTTON
Gossypium hirsutum
F: Malvaceae
This Central American shrub is the most common cultivated cotton species. The cotton fibers protect seeds inside the fruit, or boll.

SAPINDALES

The Sapindales is a large and important order, mostly of trees, shrubs, and woody vines, often with divided leaves. It includes many dominant woodland species and commercially important species such as citrus fruit. More than half its members belong to two families: the maple family (Sapindaceae), with around 1,900 species; and the rue family (Rutaceae), which mostly originate in Australia and South Africa, and has 1,700 species.

MANGO
Mangifera indica
F: Anacardiaceae
A native of Asia, mango is one of the most widely cultivated fruit in the tropical world, and is rich in vitamin A.

EVERGREEN LEAVES

59ft / 18m

RIPE FRUIT

33ft / 10m

CASHEW
Anacardium occidentale
F: Anacardiaceae
Originally from Venezuela and Brazil, this shrubby tree was taken to Asia and Africa in the 1500s, and cultivated for its nuts.

19ft / 6m

16ft / 5m

STAG'S HORN SUMACH
Rhus typhina
F: Anacardiaceae
This deciduous shrub or small tree grows on forest edges and wasteland in northeastern America. It has spiky clusters of red berries.

SMOKE BUSH
Cotinus coggygria
F: Anacardiaceae
Finely branched clusters of pale green flowers give this bush a smoky appearance. It is found in southern Europe and Asia.

»

» SAPINDALES

CRABWOOD
Carapa guianensis
F: Meliaceae
180 ft / 55 m

The dark wood of this tropical South American tree is sometimes sold as Brazilian mahogany. Soap is made from its seeds.

NEEM TREE
Azadirachta indica
F: Meliaceae

Valued for its wood, medicinal oils, and edible shoots, this tree grows throughout the Old World tropics. Indian farmers produce insecticides from the oil and leaves.

CHINESE MAHOGANY
Toona sinensis
F: Meliaceae

Chinese people eat the leaves of this east Asian tree as a vegetable. Furniture is made from its hard, reddish wood.

SCENTED BORONIA
Boronia megastigma
F: Rutaceae

This erect shrub of wet sandy sites in western Australia has bell-like flowers, brownish on the outside and golden-green inside.

FRINGED RUE
Ruta chalepensis
F: Rutaceae

From rocky habitats in southern Europe and southwestern Asia, this is thought to be the rue mentioned in the Bible.

PEPPER AND SALT
Eriostemon spicatus
F: Rutaceae

Widespread in sandy and gravely places in southwestern Australia, this low shrub has narrow leaves and pink, white, or bluish flowers.

SYDNEY ROCKROSE
Boronia serrulata
F: Rutaceae

This small shrub, in a genus confined to Australia, grows in coastal heaths near Sydney. It has bright pink, cup-shaped flowers.

MEXICAN ORANGE
Choisya ternata
F: Rutaceae

Originating from Mexico but common in gardens elsewhere, this irregular, bushy, evergreen shrub has branched clusters of sweet-scented, white flowers.

HOP TREE
Ptelea trifoliata
F: Rutaceae

This small tree native to northeastern America is grown for ornament. The flowers of the male tree are smaller than those of the female tree

SALMON CORREA
Correa pulchella
F: Rutaceae

A native of South Australia, this small shrub is grown in gardens for its delicate, pendulous, tubular flowers.

COMMON PRICKLY ASH
Zanthoxylum americanum
F: Rutaceae

This spiny North American tree grows as far north as Quebec, Canada. American Indians chewed its bark to help soothe toothaches.

SKIMMIA
Skimmia japonica
F: Rutaceae

Much planted in gardens, parks, and amenity areas, this evergreen, aromatic shrub from east Asia produces red berries in late summer.

JAPANESE BITTER ORANGE
Poncirus trifoliata
F: Rutaceae

The small, inedible yellow fruit of this spiny shrub resemble oranges with a downy skin. They have several medicinal uses.

LEMON
Citrus limon
F: Rutaceae

The Romans spread this evergreen tree throughout Europe. Thought to originate in Asia, it is widely cultivated for its fruit.

SEVILLE ORANGE
Citrus aurantium
F: Rutaceae

Unlike the sweet orange eaten raw (*C. sinensis*), this species' bitter fruit is only good for cooking. Both originate from tropical Asia.

SUGAR MAPLE
Acer saccharum
F: Sapindaceae

This tree is native to the northeastern US and southeastern Canada. Maple syrup is made by boiling sap collected from the tree in spring.

115 ft
35 m

40 ft
12 m

JAPANESE MAPLE
Acer palmatum
F: Sapindaceae

Centuries of breeding have produced many cultivated varieties of this native Japanese tree, with varying leaf shapes and spectacular fall colors.

FLOWERING STEM

WINGED SEEDS

100 ft
30 m

SYCAMORE
Acer pseudoplatanus
F: Sapindaceae

Native to mountain woods in Europe and Asia, sycamore is widely planted elsewhere. Its winged seeds spread in the wind.

40 ft
12 m

GOLDEN-RAIN TREE
Koelreuteria paniculata
F: Sapindaceae

This showy tree from east Asia is much planted in temperate regions for its cascading yellow blossoms and distinctive bladderlike seedpods.

young flowers have yellow "eye"

100 ft
30 m

LYCHEE
Litchi chinensis
F: Sapindaceae

Probably originating in southern China, this tree is cultivated for its fruit. Their sweet flesh is encased within a tough shell.

CONKER IN SPIKY SHELL

100 ft
30 m

WHITE SPRING FLOWERS

HORSE CHESTNUT
Aesculus hippocastanum
F: Sapindaceae

Native to southeast Europe, this tree is often planted for shade along city streets. Its fruit resembles chestnuts but are hard and inedible.

130 ft
40 m

BRIGHT GREEN LEAVES

EDIBLE NUTS

JAVA ALMOND
Canarium indicum
F: Burseraceae

Native to rain forests in the Pacific islands, this is one of the region's most useful trees, providing wood, oil, and edible nuts.

toothed leaves

rudder eye of older flower

26 ft
8 m

65 ft
20 m

PINNATE LEAVES

FLOWER SPIKE

26 ft
8 m

YELLOWHORN
Xanthoceras sorbifolium
F: Sapindaceae

This small tree grows wild in northern China. Its scientific name records its leaves, which resemble those of rowan (Sorbus).

TREE OF HEAVEN
Ailanthus altissima
F: Simaroubaceae

Hailing from China, this slightly rank-smelling tree is planted along city streets because it endures pollution and most soil types.

BITTERWOOD
Quassia amara
F: Simaroubaceae

Boiled extracts from the bark and wood of this tree are used to make tonics against malaria in tropical America.

FRANKINCENSE
Boswellia sacra
F: Burseraceae

Frankincense, a gum resin used in incense and to fix perfumes, oozes as milky juice from cuts in trunks of these Arabian trees.

CORNALES

Although the scope of the Cornales varies between different classification systems, it is used here as a small order of just five or six families. The main family is the dogwood family (Cornaceae), a loose taxonomic grouping of shrubs and small trees found in temperate zones and on tropical mountains. It also includes the hydrangea family (Hydrangeaceae), represented by several popular garden plants.

HYDRANGEA
Hydrangea macrophylla
F: Hydrangeaceae
Native to China and Japan, this showy shrub is cultivated for its rounded clusters of rose, lavender, blue, and even white flowers.

5 ft/1.5 m

FLOWERING DOGWOOD
Cornus florida
F: Cornaceae
The showy white "petals" of this North American dogwood tree are bracts (specialized leaves) around clusters of tiny flowers.

40 ft
12 m

DOVETREE
Davidia involucrata
F: Cornaceae
This small flowering tree from southwestern China is impressive in bloom, with flower heads ¾ in (2 cm) across, surrounded by creamy bracts.

80 ft
25 m

MOCK ORANGE
Philadelphus sp.
F: Hydrangeaceae
Around 65 species of this shrubby genus, named for their orange-blossom fragrance, are native to western North America, Asia, and Mexico.

15 ft
4.5 m

ERICALES

The Ericales is an important order, both economically and as a one of the world's main herbaceous groups. It includes the acid-soil loving heather family (Ericaceae), with over 4,000 species of flowering shrubs; and the primrose family (Primulaceae), found mostly in the mountain habitats of northern temperate regions; and carnivorous plants in the pitcher plant family (Sarraceniaceae).

CORALBERRY
Ardisia crenata
F: Myrsinaceae
A greenhouse favorite for its long-lasting, bright berries, this Asian shrub has become an invasive pest in Hawaii, Florida, and Texas.

6 ft
1.8 m

3¼ ft
1 m

JACOB'S LADDER
Polemonium caeruleum
F: Polemoniaceae
This tall perennial has cup-shaped lavender or white flowers. It grows in rocky and grassy places in North America and northern and central Europe.

3¼ ft/1 m

PERENNIAL PHLOX
Phlox paniculata
F: Polemoniaceae
A pyramidal cluster of trumpet-shaped, pink or lavender flowers top the stem of this perennial, native to open woods in the southeastern US.

scarlet, bell-shaped flowers

50 ft / 15 m

TREE RHODODENDRON
Rhododendron arboreum
F: Ericaceae

There are about 850 species of *Rhododendron*, most with leathery, evergreen leaves and showy flowers. Many, like this one, come from the Himalayas.

3–6 ft / 1 m

HEATHER
Calluna vulgaris
F: Ericaceae

This evergreen shrub, with spikes of pale purple flowers, dominates vast areas of moorland in northern Europe and eastern North America.

24 in / 60 cm

DORSET HEATH
Erica species
F: Ericaceae

One of several, similar spiky *Ericae*, this species is known from southern England (including Dorset), as well as western Ireland and France.

40 ft / 12 m

STRAWBERRY TREE
Arbutus unedo
F: Ericaceae

Although related to heathers, the warty, red fruit of this evergreen Mediterranean tree look remarkably like strawberries but taste insipid.

WHITE, BELL-SHAPED FLOWERS

1–2 ft / 30 cm

ACIDIC BERRIES

COWBERRY
Vaccinium vitis-idaea
F: Ericaceae

This neat heather, with leathery leaves and glossy red berries in fall, is found across North America, northern Europe, and Asia.

16 ft / 5 m

HIMALAYAN PIERIS
Pieris formosa
F: Ericaceae

Formosa means "beautiful," a reference to the hanging clusters of white, urn-shaped flowers on this Asian bush or small tree.

thick trunk covered in small leaves

65 ft / 20 m

6 in / 15 cm

CHECKERBERRY
Gaultheria procumbens
F: Ericaceae

This creeping, aromatic shrub forms patches beneath oaks and conifers in eastern North America. Its red fruit lasts through the winter.

10 ft / 3 m

SWEET PEPPER BUSH
Clethra alnifolia
F: Clethraceae

This deciduous shrub grows in wet forests and bogs in eastern North America. Its leaves turn yellow or orange in fall.

DECIDUOUS LEAVES

ORANGE BERRIES

65 ft / 20 m

PERSIMMON
Diospyros virginiana
F: Ebenaceae

This native North American tree has yellowish white, bell-shaped flowers and produces globular orange fruit, about 1½ in (4 cm) across.

6 ft / 2 m

INDIAN BALSAM
Impatiens glandulifera
F: Balsaminaceae

Exploding fruit pods, which shoot their seeds outward, have helped this Himalayan species become established by rivers in most of Europe.

33 ft / 10 m

black seeds

OPEN FRUIT

FRUIT

KIWI
Actinidia chinensis
F: Actinidiaceae

Also known as Chinese gooseberry, this woody climber was introduced from China to New Zealand, where the berries were sold as "kiwi fruit."

165 ft / 50 m

ROUND, WOODY FRUIT

BRAZIL NUT
Bertholletia excelsa
F: Lecythidaceae

Brazil "nuts" are actually seeds inside this South American tree's hard, cannonball-like fruit. In the wild, agoutis (large rodents) open the fallen fruit.

MULTIPLE "NUTS" INSIDE

BOOJUM TREE
Fouquieria columnaris
F: Fouquieriaceae

This strange tree is mainly confined to Baja, California, US. Its stem and upright, spiny branches are green and can photosynthesize.

65 ft / 20 m

»

HOODED PITCHER PLANT

Sarracenia minor

This insectivorous plant is highly adapted to living in nutrient-poor, acidic environments, digesting insects to obtain the phosphorus and nitrogen from their bodies. Insects are attracted by nectar into the pitcher, the long thin tube of modified leaves from which the plant gets its name. The interior of the pitcher is covered in a slippery waxy coating and downward-pointing hairs that become coarser nearer the bottom of the tube. The insects fall in and, unable to get out, eventually die from exhaustion. Digestive glands in the tube walls exude enzymes which break down the insects, resulting in a liquid slurry that is then absorbed into the leaf, providing the pitcher plant with valuable nutrients.

SIZE Up to 12 in (30 cm) tall
HABITAT Upland savanna, wet pinewood, bogs
DISTRIBUTION Southeast USA
LEAF TYPE Hooded, narrow, hollow cone or ascidium

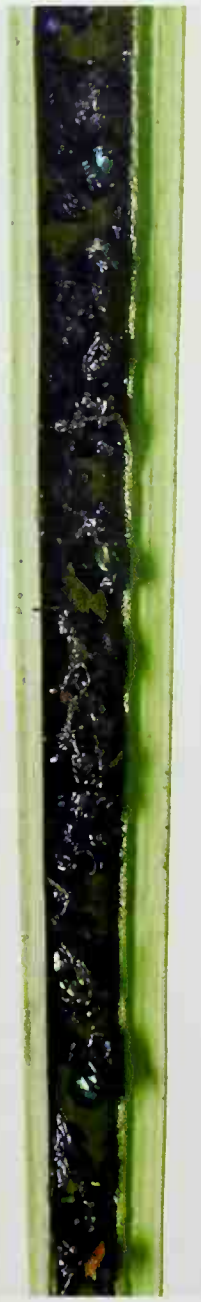
FLOWER ∨
The flowers have five sepals, five yellow petals (which redden as they mature), and a whitish, umbrella-like style. They hang upside down.

SEED CAPSULE ∨
The broad, rough capsules crack open and scatter many tiny knobbly seeds, which are about ⅛ in (3 mm) long.

RHIZOME ∨
The plant's domed pitchers rise up from a horizontally branching, underground stem known as a rhizome.

ROOTS >
The fibrous roots are 8–12 in (20–30 cm) long and grow along the length of the rhizome.

^ "WINDOWS"
Insects fly toward the bright translucent "windows" or areoles on the upper part of the pitcher, but then fall into the tube.



^ INSECT TRAP
Insects caught in the pitcher find it very difficult to escape. The leaf digests the soft parts, but the skeletons remain.

^ IN BLOOM
The yellow, odorless flowers are produced from late March to mid-May. Bees are the main pollinator, and will prefer this species over other nearby plants.

reddish purple colors of the hood attract insects to the pitcher

< HOODS
The concave hoods prevent rainwater from filling up the pitcher and also shade the opening, making it harder for trapped insects to find the exit.

nectar glands at the back of the hood

< CARNIVORE AT RISK
The hooded pitcher plant is now rare and a threatened species due to habitat loss. It is found in North Carolina, South Carolina, Georgia, and Florida. There are two varieties: *S. minor* grows to 12 in (30 cm), while *S. minor* var. *okefenokeensis* grows up to 4 ft (1.2 m) and is found only at Okefenokee Swamp in Georgia.

40 ft/12 m

EPAULETTE TREE
Pterostyrax hispidus
F: Styracaceae

Native to east Asia, this large-leaved, deciduous tree is sometimes cultivated for its hanging clusters of fragrant, creamy-white flowers.

15 ft
4.5 m

SILKY CAMELLIA
Stewartia malacodendron
F: Theaceae

Named after its silkily haired young stems, this deciduous shrub or small tree grows in woodland in eastern USA.

30 ft/10 m

GRANTHAM'S CAMELLIA
Camellia granthamiana
F: Theaceae

One of around 80 *Camellia* species, all from Asia, this endangered tree from China was discovered in 1955.

56 ft/17 m

TEA
Camellia sinensis
F: Theaceae

The dried fermented leaves and buds of this evergreen Asian shrub are used to make tea. Their astringent tannins deter grazing animals.

protruding red stamen

18 in/45 cm

PINKEY PITCHER PLANT
Sarracenia x *stevensii*
F: Sarraceniaceae

In pitcher plants, like this hybrid, insects, attracted by nectar, fall into pitcher-shaped leaves, where they get trapped and are digested by enzymes.

3¼ ft
1 m

YELLOW PITCHER PLANT
Sarracenia flava
F: Sarraceniaceae

Pitcher plants trap and digest insectsto supplement their nutrient-poor diet. This species is native to southeast USA.

14 in
35 cm

PARROT PITCHER PLANT
Sarracenia psittacina
F: Sarraceniaceae

Sarracenia species grow wild only in eastern North America. The pitchers of this species, found from Florida to Louisiana, form horizontal traps.

26 ft/8 m

SPANISH CHERRY
Mimusops elengi
F: Sapotaceae

This evergreen Indian tree is planted in tropical countries for its fragrant flowers. Its durable wood is used in shiphuilding and construction.

rough, hairy, lanceolate leaf

3¼ ft/1 m

hood resembles cobra ready to strike

COBRA PLANT
Darlingtonia californica
F: Sarraceniaceae

The only species of *Darlingtonia*, this carnivorous plant grows in coastal hogs and beside mountain streams in western USA.

20 in/50 cm

TANSY PHACELIA
Phacelia tanacetifolia
F: Boraginaceae

Mostly annuals of dry places, phacelias flower prolifically after rain. More than 80 members of this genus are found in California.

3¼ ft/1 m

VIPER'S-BUGLOSS
Echium vulgare
F: Boraginaceae

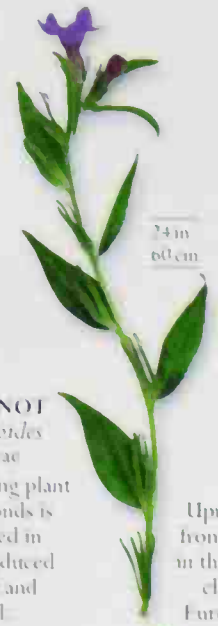
Widespread in grassy places in Europe and temperate Asia, this rough-haired biennial has pinkish flower buds but deep blue flowers.

COMMON COMFREY
Symphytum officinale
F: Boraginaceae

Symphytum means "growing together," named because this perennial of damp ground throughout Eurasia was traditionally used in the treatment of injuries.

WATER FORGET-ME-NOT
Myosotis scorpioides
F: Boraginaceae

This surface-breaking plant of streams and ponds is widely distributed in Eurasia, and introduced to the Americas and New Zealand.



PURPLE GROMWELL
Buglossoides purpureocaerulea
F: Boraginaceae

Upright flower stems grow from creeping ground stems in this woodland perennial of chalky soils in southern Europe and southwest Asia.

CREEPING JENNY
Lysimachia nummularia
F: Primulaceae

From Sweden eastward to the Caucasus, this creeping perennial with rounded leaves grows in damp grassy places, shady hedgerows, and streamsides.

COMMON LUNGWORT
Pulmonaria officinalis
F: Boraginaceae

With blotched leaves supposedly resembling unhealthy lungs, and once thought to be efficacious against tuberculosis, this perennial grows in shady places throughout central Europe.

BORAGE
Borago officinalis
F: Boraginaceae

Stiff hairs cover the stem and leaves of this southern European wayside plant, also cultivated for ornament and its oil-rich seeds.

SCARLET PIMPERNEL
Anagallis arvensis
F: Primulaceae

Just as likely to have deep blue as scarlet flowers, this sprawling plant grows in disturbed ground virtually worldwide, except the tropics.

COWSLIP
Primula veris
F: Primulaceae

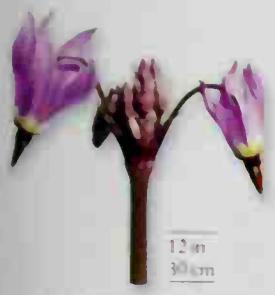
A typical primrose, with a head of up to 30 nodding flowers, cowslip grows in lime-rich meadows in S. Europe and temperate Asia.

WILD PRIMROSE
Primula sp.
F: Primulaceae

Supposedly the *prima rosa* or "first flower" of spring, this perennial grows in woodland clearings and hedgebanks in western and southern Europe.

NORTHERN PRIMROSE
Primula scandinavica
F: Primulaceae

Growing on mountain slopes in Norway and Sweden, this resembles the more common European birdseye primrose, but is much smaller.



MOSQUITO BILLS
Dodecatheon hendersonii
F: Primulaceae

Dodecatheon flowers are called "shooting stars" because of their rocket or dart shapes. This western North American species has magenta to white flowers.

HAIRY ANDROSACE
Androsace villosa
F: Primulaceae

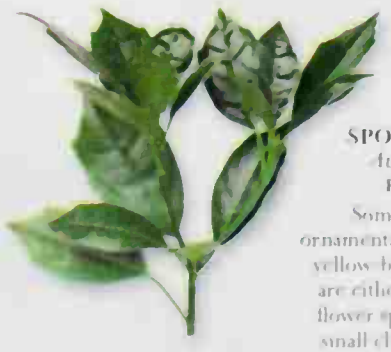
In a genus of arctic-alpines, this perennial of the mountains of southern Europe is distinguished by its silky leaves and dense white flowerheads.

HARDY CYCLAMEN
Cyclamen hederifolium
F: Primulaceae

Cyclamen leaves grow from underground stems, their tubular autumn flowers have back-folded petals. This species grows in bushy places in southern Europe.

GARRYALES

Any classification system raises anomalies, and the order Garryales is one of these. Once placed in the Cornales, modern chemical investigation separated this order of two families and around 20 species. The silky tassel family (Garryaceae) includes two genera: *Garrya* from North America and *Aucuba* from Eastern Asia. The Eucommiaceae covers just one species: *Eucommia ulmoides*, a tree of Chinese mountain forests.



SPOTTED LAUREL
Aucuba japonica
F: Garryaceae

Some cultivars of this ornamental Japanese shrub grow yellow-blotched leaves. Plants are either male, with upright flower spikes, or female with small clustered flowerheads.

SILK-TASSEL BUSH
Garrya elliptica
F: Garryaceae

Growing in coastal scrub in California and Oregon, this small tree has showy, gray-green male catkins and shorter, silvery female catkins.

GENTIANALES

The order name celebrates the gentians of mountains and gardens, but the Gentianaceae is a small family. There are five families, the largest is the madder family (Rubiaceae), with over 13,000 species, including tropical shrubs such as coffee. The oleander family (Apocynaceae), strychnine family (Loganiaceae), and jessamine family (Gelsemiaceae) complete the order.

3¼ ft
1 m

MADAGASCAR PERIWINKLE
Catharanthus roseus
F: Apocynaceae

The leaves of this garden ornamental, endangered in its native Madagascar, contain tiny amounts of alkaloids used to treat childhood leukemias. This use has saved it from extinction.

50 ft
15 m

FIVE-PETALED FLOWER

OVAL LEAF

COMMON FRANGIPANI
Plumeria rubra
F: Apocynaceae

Native from Mexico to the Caribbean islands, the flowers of this ornamental tree are fragrant at night and attract sphinx moths for pollination.

6 in/15 cm

BEAD PLANT
Nertera granadensis
F: Rubiaceae

Named for its small, beadlike fruits, this perennial with tiny, green flowers is native to Australia, New Zealand, and South America.

5 ft
1.5 m

GREATER PERIWINKLE
Vinca major
F: Apocynaceae

Long, rooting stems of this evergreen perennial creep across woodland floors in southern and central Europe and North Africa.

13 ft/4 m

OLEANDER
Nerium oleander
F: Apocynaceae

All parts of this evergreen shrub are poisonous. It grows by streams from the Mediterranean to China, producing clusters of fragrant pink flowers.

30 in
75 cm

BUTTERFLY WEED
Asclepias tuberosa
F: Apocynaceae

American Indians chewed roots as a cure for pleurisy. This perennial grows in fields and on roadsides in eastern North America.

10 ft
3 m

CLEAVERS
Galium aparine
F: Rubiaceae

Prickles on the stem and leaf margins attach to animal fur, dispersing parts of this agricultural weed of Europe and western Asia.

glossy, evergreen leaf

CROSSWORT
Cruciata laevipes
F: Rubiaceae

With stem leaves in crosslike whorls and clustered, honey-scented flowers, this perennial grows in grassy places across Europe and Asia.

24 in
60 cm

succulent, leafless stem

50 ft
15 m

QUININE TREE
Cinchona calisaya
F: Rubiaceae

The antimalaria drug quinine comes from the bark of this South American tree. Seeds were smuggled to Asia in the mid 19th century for cultivation there.

33 ft/10 m

fruits red when ripe

COFFEE SHRUB
Coffea arabica
F: Rubiaceae

Native to Ethiopia but transported elsewhere for cultivation, this evergreen shrub produces crimson drupes (stoned fruit) within which are two seeds (coffee beans).

6½ ft
2 m

CAPE JASMINE
Gardenia augusta
F: Rubiaceae

Originating in Asia, this evergreen shrub has fragrant, waxy, tubular white flowers that turn yellow with age. These ripen to berrylike fruits.

EGG-SHAPED LEAVES

82 ft
25 m

STRYCHNINE SEEDS

STRYCHNINE
Strychnos nux-vomica
F: Loganiaceae
The poison strychnine comes from seeds of this evergreen tree from southeast Asia.

12 in
30 cm

PERSIAN VIOLET
Exacum affine
F: Gentianaceae
Grown as an indoor ornamental but native to Socotra Island in the Indian Ocean, this evergreen biennial has purple flowers with yellow centers.

20 in
50 cm

COMMON CENTAURY
Centaurium erythraea
F: Gentianaceae
Grassy places and dunes from Europe to southwest Asia are home to this annual with funnel-shaped, five-lobed pink flowers.

5 in
12 cm

rosette of oval leaves

SPRING GENTIAN
Gentiana verna
F: Gentianaceae
With ground-level leaf rosettes and deep blue, tubular flowers, this perennial grows in Arctic and mountain regions of Europe and Asia.

12 in
30 cm

flower's center emits stench of rotting meat

hairy-edged petals

CARRION FLOWER
Stapelia gettleffii
F: Apocynaceae
Carrion flowers are succulent, spiny plants from southern Africa. The stench of their barred or blotched flowers attracts carrion flies as pollinators.

20 ft
6 m

MADAGASCAR JASMINE
Stephanotis floribunda
F: Gentianaceae
Originally from Madagascar, this woody, twining vine is a popular greenhouse plant with leathery leaves and clusters of fragrant, waxy, white flowers.

LAMIALES

Modern taxonomy has expanded the scope of this order to include up to 21 families, typically with tubular flowers and unequal petal lobes. The largest are the mint family (Lamiaceae, often known by its older name Labiatae) and the figwort family (Scrophulariaceae), each with 5,000–6,000 species. Others include the olive family (Oleaceae) and plantain family (Plantaginaceae).

1.5 m
5 ft

dark green leaf with creamy veins

ZEBRA PLANT
Aphelandra squarrosa
F: Acanthaceae
Originating from coastal Brazilian forests, this popular houseplant has pale-veined leaves and spikes of yellow flowers surrounded by yellow specialized leaves.

STOUT FLOWER SPIKE

CRINKLY LOBED LEAF

3¼ ft
1 m

BEAR'S BREECHES
Acanthus mollis
F: Acanthaceae
This robust perennial of rocky places in the western Mediterranean has spikes of purple-veined white flowers with a three-lobed lower lip.

20 in
50 cm

SHRIMP BUSH
Justicia brandegeana
F: Acanthaceae
This popular ornamental from tropical America and the Caribbean has white, tubular, two-lipped flowers surrounded by a reddish, shrimp-shaped leaves.

50 ft
15 m

BLACK MANGROVE
Avicennia germinans
F: Acanthaceae
This tree forms thickets beside tidal estuaries along tropical Atlantic coasts. Pointed fruits, falling into the mud, sprout new plants.

12 in
30 cm

BUGLE
Ajuga reptans
F: Lamiaceae

Growing around Europe, North Africa, and Southwest Asia, this woodland and meadow perennial produces flower stems from far-creeping, rooting runners.

tubular flower with large three-lobed lip

oval leaves, often bronzy underneath

20 ft/6 m

CHASTE TREE
Vitex agnus-castus
F: Lamiaceae

Chaste tree, from damp places in southern Europe, was once thought to preserve chastity. It is used to regulate hormonal functions in alternative herbal treatments.

10 ft/3 m

ROUND-LEAVED MINT BUSH
Prostanthera rotundifolia
F: Lamiaceae

This aromatic Australian shrub with circular leaves and pink to purple spring flowers grows in open forests from Queensland to Tasmania.

24 in/60 cm

SAGE
Salvia officinalis
F: Lamiaceae

This grayish shrub from Spain, southern France, and the Balkans is widely cultivated for its pungent leaves, used to flavour foods.

5 ft
1.5 m

JERUSALEM SAGE
Phlomis fruticosa
F: Lamiaceae

Native to dry rocky habitats in the eastern Mediterranean, this evergreen shrub with gray-felted leaves is a widely grown garden ornamental.

1¼ ft/40 cm

COMMON THYME
Thymus vulgaris
F: Lamiaceae

Native to dry rocky places in the western Mediterranean, this densely branched shrub is used as a culinary herb, and an ingredient in perfumes and soaps.

6½ ft/2 m

ROSEMARY
Rosmarinus officinalis
F: Lamiaceae

From dry Mediterranean habitats, the oils in the leaves of this shrub reduce potential water loss from transpiration. Rosemary is a well-known culinary herb.

LATE SUMMER FLOWERS

32 in
80 cm

EDIBLE LEAVES

BASIL
Ocimum basilicum
F: Lamiaceae

Also known as sweet basil, this is an annual from India and Iran. In cultivation, its pungent leaves are used as a culinary herb.

LANCEOLATE LEAF

CLUSTER OF FLOWERS

4 ft
1.2 m

WILD BERGAMOT
Monarda fistulosa
F: Lamiaceae

A minty tea is made from the grayish leaves of this showy American perennial of dry fields and thickets from New England to Texas.

3¼ ft
1 m

WATER MINT
Mentha aquatica
F: Lamiaceae

Growing part-submerged in ponds and ditches in Europe, Africa, and Southwest Asia, this herb is one parent of the hybrid peppermint.

32 in
80 cm

COMMON LAVENDER
Lavandula angustifolia
F: Lamiaceae

This is another evergreen shrub of dry Mediterranean scrub habitats. The water-saving oils in its leaves are valued in perfumery.

DENSELY PACKED FLOWERS

32 in
80 cm

BETONY
Betonica officinalis
F: Lamiaceae

A common hedgerow and grassland herb in most of Europe, the Caucasus, and North Africa, betony has reddish purple or white flowers.

branched cluster of pinkish purple flowers

3¼ ft/1 m

WILD MARJORAM
Origanum vulgare
F: Lamiaceae

A perennial aromatic herb of grassy and stony habitats in southern Europe and southwest Asia, it is grown for many culinary uses.

stalked, oval leaf

OLIVE
Olea europaea
F: Oleaceae

The fleshy fruits of this evergreen Mediterranean tree contain 40 percent unsaturated oils. Before they are eaten, the olives must be pickled in brine.

GOLDEN BELL
Forsythia suspensa
F: Oleaceae

Also called weeping forsythia, this deciduous shrub has hollow, pendulous stems and yellow flowers. It is native to China and perhaps Japan.

MANNA ASH
Fraxinus ornus
F: Oleaceae

This unusual ash from southern Europe has dense clusters of white flowers. Manna, a sugary gum from its bark, is used medicinally.

LILAC
Syringa vulgaris
F: Oleaceae

Gardeners have developed many hybrids and varieties of this showy, deciduous tree, found wild on scrubby hillside in southeast Europe.

FALSE AFRICAN VIOLET
Streptocarpus saxorum
F: Gesneriaceae

Originating from Kenya and Tanzania, this evergreen perennial has whorls of small, hairy, almost succulent leaves and five-lobed, trumpet-shaped flowers.

AFRICAN VIOLET
Saintpaulia tongwensis
F: Gesneriaceae

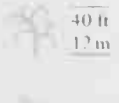
Popular houseplants, African violets live in rain forests in tropical East Africa. Most of the 20 species are endangered in the wild.

INDIAN BEAN TREE
Catalpa bignonioides
F: Bignoniaceae

Despite its common name, this woodland tree grows in southern USA. It is planted farther north and in Europe for its showy flowers.

HARDY GLOXINIA
Incarvillea delavayi
F: Bignoniaceae

A hardy garden perennial with rosy-purple trumpet flowers, this herbaceous plant grows wild in mountain grasslands in India, Tibet, and China.



COMMON JASMINE
Jasminum officinale
F: Oleaceae

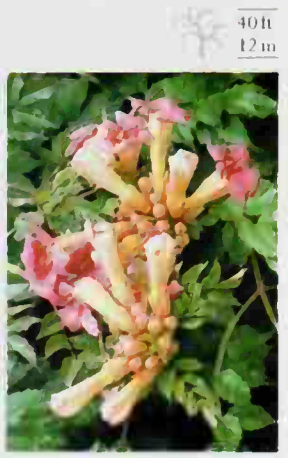
Cultivated for its showy scented flowers, this scrambling, deciduous shrub from the Caucasus to China twists counter-clockwise as it climbs.

JACARANDA
Jacaranda mimosifolia
F: Bignoniaceae

Originally from Argentina and Brazil, this tropical tree with hanging clusters of lavender-colored flowers is widely planted for shade and ornament.

COMMON BUTTERWORT
Pinguicula vulgaris
F: Lentibulariaceae

This bog plant from northern Europe, Asia, and North America gets nutrients by trapping and digesting insects on its sticky leaves.



TRUMPET VINE
Campsis x tagliabuana
F: Bignoniaceae

A garden hybrid between a North American and an Asian species, this vigorous climbing shrub has clusters of orange-red, trumpet-shaped flowers.

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SHRUBBY GLOBULARIA
Globularia alypum
F: Plantaginaceae
Growing in dry, bushy places around the Mediterranean, this poisonous, low, evergreen shrub has globular heads of sweet-scented, blue flowers.

MARE'S-TAIL
Hippuris vulgaris
F: Plantaginaceae
Wholly or partly submerged, this aquatic perennial from Europe, Asia, Africa, and South America has whorls of narrow leaves up its stem. A rapid grower, mare's-tail is a major garden pest.

RIBWORT PLANTAIN
Plantago lanceolata
F: Plantaginaceae
A plant of grassy places, with narrow oblong, strongly veined leaves and a cylindrical flowerhead, this perennial grows in most temperate regions.

GREATER PLANTAIN
Plantago major
F: Plantaginaceae
This variable plantain grows in open habitats, including trampled ground in gardens, throughout Europe, North Africa, and northern and central Asia.

HEATH SPEEDWELL
Veronica officinalis
F: Plantaginaceae
A denizen of European and Asian heathlands, also introduced to North America, this creeping perennial has a pyramidal stems of lilac flowers.

FOXGLOVE
Digitalis purpurea
F: Scrophulariaceae
The heart drug digitalis is extracted from dried leaves of this open-ground biennial from central and southern Europe and Morocco.

BEARDTONGUE
Penstemon sp.
F: Scrophulariaceae
The 250 members of this North American genus, which is common in the western USA, have large, colorful, tubular flowers.

SNAPDRAGON
Antirrhinum majus
F: Scrophulariaceae
Native to southwestern Europe but with many garden varieties, this perennial has tubular, two-lipped flowers, with a yellow or white throat.

MONKEY FLOWER
Mimulus guttatus
F: Scrophulariaceae
The tubular flowers of this marshland and streamside perennial from northwest America have a three-lobed lower and two-lobed upper lip.

GREAT MULLEIN
Verbascum thapsus
F: Scrophulariaceae
Usually biennial, this sturdy European and Asian plant of waste and rough ground has a dense stem of tubular, five-lobed flowers.

PURPLE TOOTHWORT
Lathraea clandestina
F: Scrophulariaceae
Lacking green leaves, this parasitic European perennial taps the roots of willows and poplars for food. Its flowerheads emerge directly from underground shoots.

BUTTERFLY BUSH
Buddleja davidii
F: Scrophulariaceae
The tubular flowers of this semi-evergreen shrub, originally from China, are a rich source of nectar, and much visited by butterflies and moths.

COMMON TOADFLAX
Linaria vulgaris
F: Scrophulariaceae
This grayish perennial of grassy banks around Europe and western Asia has tubular yellow flowers with orange "throat" and long spur.

FOXGLOVE TREE
Paulownia tomentosa
F: Scrophulariaceae
A deciduous Chinese tree, planted in parks for ornament, *Paulownia* has strong-smelling, trumpet-shaped, two-lobed purple flowers, paler inside.

YELLOW RATTLE
Rhinanthus minor
F: Scrophulariaceae
A partial parasite whose roots tap grasses for nutrition, this variable, yellow-flowered annual grows in grasslands in northern temperate regions.

SPOTTED EMU BUSH
Eremophila maculata
F: Scrophulariaceae
Widespread on seasonally flooded land across Australia, this much-branched shrub has tubular yellow, orange, or red flowers, with spots inside.

NEW ZEALAND LILAC
Veronica hulkeana
F: Plantaginaceae

This evergreen shrub, also known as a hebe, is a popular garden plant. It has showy stems of lilac flowers, growing wild on cliffs on the eastern side of New Zealand's South Island.

***HEBE* "RED EDGE"**
Veronica sp.
F: Plantaginaceae

Often used in landscaping schemes, this hardy hebe cultivar is thought to be a cross between *Veronica albicans* and *Veronica pimeleoides*.

FLAMING GLORYBOWER
Clerodendrum splendens
F: Verbenaceae

This African vine, with clusters of tubular, red flowers, twines around trees in its native forest habitat, or trellises in gardens.

BODINIER'S BEAUTYBERRY
Callicarpa bodinieri
F: Verbenaceae

Related to American beautyberry, this Chinese ornamental shrub is grown in gardens for its decorative purple berries, which are bitter but not poisonous.

LANTANA
Lantana camara
F: Verbenaceae

The tubular flowers of this prickly shrub open yellow or orange then turn red. Native to the Americas, it is one of the most invasive weeds in warm regions.

VERVAIN
Verbena officinalis
F: Verbenaceae

Widely distributed in rough grassland in temperate and tropical regions, this stiffly hairy perennial has slender spikes of two-lipped, lilac flowers.

SOLANALES

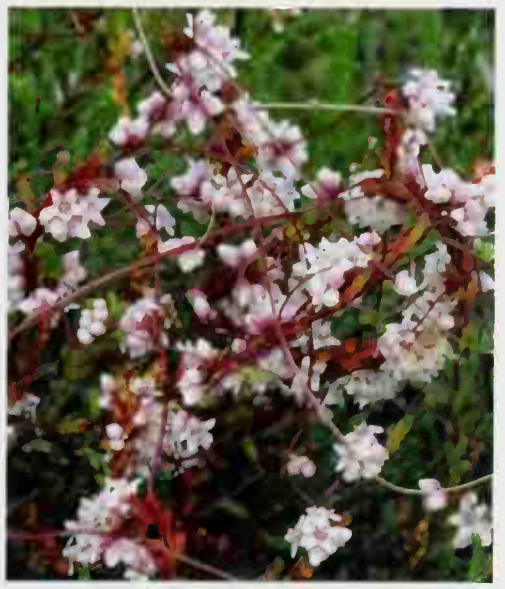
The potato family (Solanaceae), an economically important family of up to 4,000 species, dominates the order Solanales. Many species contain poisonous alkaloids. The bindweed family (Convolvulaceae) includes tropical climbers and low-growing herbs. Other families within this order are the Hydrolaceae, with one genus found in the Americas; five African trees in the Montiniaceae; and a pan-tropical herb in the Sphenocleaceae.

GREAT BINDWEED
Convolvulus sylvaticus
F: Convolvulaceae

A plant of hedgerows and waste ground, even in cities, and native to the Mediterranean, this large-flowered perennial spreads by far-creeping rhizomes (underground plant stems).

MORNING GLORY
Ipomoea tricolor
F: Convolvulaceae

This twining herbaceous climber from tropical America has lobed leaves and funnel-shaped flowers that open only in the morning.



COMMON DODDER
Cuscuta epithymum
F: Convolvulaceae

An annual forming a dense network of threadlike, twining stems, parasitic dodder taps into gorse, heather, and other species for food.

» SOLANALES

THORN-APPLE
Datura stramonium
F: Solanaceae

Rank-smelling and highly poisonous, this widespread annual weed is thought to originate from America.

DEADLY NIGHTSHADE
Atropa belladonna
F: Solanaceae

Packed with powerful narcotics and truly deadly, this tall, perennial herb grows in woods and scrub in Europe, North Africa, and western Asia.

RED ANGELS' TRUMPETS
Brugmansia sanguinea
F: Solanaceae

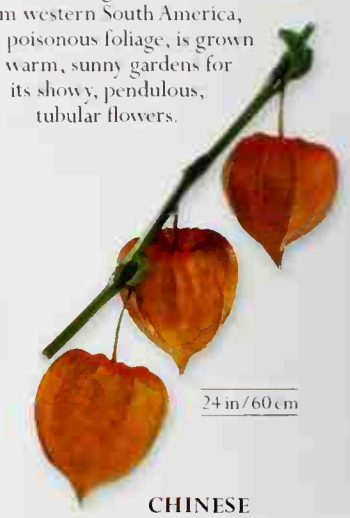
This evergreen tree from western South America, with poisonous foliage, is grown in warm, sunny gardens for its showy, pendulous, tubular flowers.

HENBANE
Hyoscyamus niger
F: Solanaceae

Poisonous, narcotic, and evil-smelling, this annual herb inhabits disturbed ground, especially where cattle graze, in Europe, Asia, and North Africa.

TOMATO
Solanum lypopersicum
F: Solanaceae

Probably bred originally from yellow-fruited cherry tomatoes from Peru and Ecuador, this short-lived perennial is cultivated for its fleshy, edible berries.



CHINESE LANTERN
Physalis alkekengi
F: Solanaceae

From southern Europe despite its name, this relative of cape gooseberry is mainly grown for ornament. A lantern-shaped flower conceals its berry.

APIALES

The order Apiales is dominated by the highly distinctive and economically important carrot family (Apiaceae, often known by the older name Umbelliferae), with at least 3,500 species. The Araliaceae, consisting of ivies and ginseng, is another large family, while the parchment-bark family, Pittosporaceae, of evergreen shrubs and trees is medium-sized. Seven smaller families, with few species, complete the order.

WILD ANGELICA
Angelica sylvestris
F: Apiaceae

A typical "umbellifer" this plant has with 15–40 umbrella-like spokes supporting its flower-bearing stem. Angelica grows in grassy places in Europe and temperate Asia.

ASTRANTIA
Astrantia major
F: Apiaceae

A plant of alpine meadows and open woods throughout Europe, astrantia has showy pinkish bracts, or specialized leaves, under its heads of small flowers.

HOGWEED
Heracleum sphondylium
F: Apiaceae

With hollow, hairy stems and umbrella-shaped flower heads with 10–20 stems, hogweed grows in roadsides from eastern Europe to Britain.

GIANT FENNEL
Ferula communis
F: Apiaceae

This robust, giant perennial, with pungent-smelling, hollow stems, grows in grassy and meadowy places around the Mediterranean, Asia, and North Africa.

HEMLOCK
Conium maculatum
F: Apiaceae

A biennial of wet places in Europe and Asia, widely introduced elsewhere, hemlock has hollow, purple-spotted stems. All parts are poisonous.

WILD CARROT
Daucus carota
F: Apiaceae

The wild ancestor of cultivated carrots has just slightly swollen tap-roots. It grows throughout Europe, temperate Asia, and North Africa.

4 ft
1.2 m

HOT PEPPER
Capsicum frutescens
F: Solanaceae

Much cultivated in tropical Asia and equatorial America, peppers are South American natives. The fruit of this small shrub are chilies.

10 ft
3 m

TOBACCO
Nicotiana tabacum
F: Solanaceae

Originally South American, this herb is the most common of two species grown for smoking tobacco. The leaves contain nicotine.

3½ ft
1 m

FLOWERS AND PINNATE LEAVES

POTATO
Solanum tuberosum
F: Solanaceae

Potatoes are a major food crop. The swollen tubers turn green (and poisonous) in sunlight. The plant was bred from South American ancestors.

EDIBLE TUBERS

berrylike red fruit

33 ft
10 m

egg shaped flower head

KOHUHU
Pittosporum tenuifolium
F: Pittosporaceae

Growing wild in mountain forests on both islands of New Zealand, this evergreen tree has almost black branches and honey-scented spring flowers.

24 in / 60 cm

leathery, spiny leaves

SEA HOLLY
Eryngium maritimum
F: Apiaceae

Leathery leaves help this sturdy perennial reduce water loss and repel salt spray in sand dunes around Europe, North Africa, and southeastern Asia.

32 in / 80 cm

ORIENTAL GINSENG
Panax ginseng
F: Araliaceae

The root of this Asian herb is used as a traditional remedy. Its species name, *Panax*, comes from the Greek word *panacea*, meaning a cure-all for diseases.

80 ft / 24 m

COMMON HOLLY
Ilex aquifolium
F: Aquifoliaceae

An evergreen, woodland understorey shrub or small tree from Europe, North Africa, and northwestern Asia, holly has spiny leaves to discourage grazers.

150 ft
50 m

IVY
Hedera helix
F: Araliaceae

An evergreen shrub from Europe and southwestern Asia, ivy climbs up other plants or forms creeping carpets in woods.

AQUIFOLIALES

The mainly tropical holly family (Aquifoliaceae) includes trees and shrubs with characteristically toothed leaves, and is the main representative of the Aquifoliales order. Other members of this small and recent order are an odd family of twining herbs, the Cardiopteridaceae; three Asian shrubs in the Helwingiaceae; four South American shrubs and trees in the Phyllonomaceae; and a family of tropical trees, the Stemonuraceae.

ASTERALES

Around 13 families make up the Asterales. The largest is the daisy family (Asteraceae) with some 25,000 species. Typically, each flowerlike head (capitula) has many individual flowers, called florets, surrounded by showy rays. Some of the bellflower family (Campanulaceae) show similar characteristics. This order includes the bogbean (Menyanthaceae) and the fan-flower (Goodeniaceae) families, and several smaller families.

MICHAELMAS DAISY
Symphotrichum novi-belgii
F: Asteraceae

Previously classified as a species of *Aster*, this showy, variable garden plant is a native of eastern North America.

SALSIFY
Tragopogon porrifolius
F: Asteraceae

A biennial herb of grassy places around the Mediterranean, salsify has lilac or reddish purple flowerheads, surrounded by longer, pointed bracts.

capitula of disk florets, which mature into seed
lobed ray florets may be yellow, orange, or maroon
oval, toothed leaf
tall, robust stem
11½ ft
3.5 m

SUNFLOWER
Helianthus annuus
F: Asteraceae

Probably Mexican in origin, this tall annual is grown as an ornamental as well as commercially for its seeds, which contain 27–40 percent polyunsaturated oil and 13–20 percent protein.

CORNFLOWER
Centaurea cyanus
F: Asteraceae

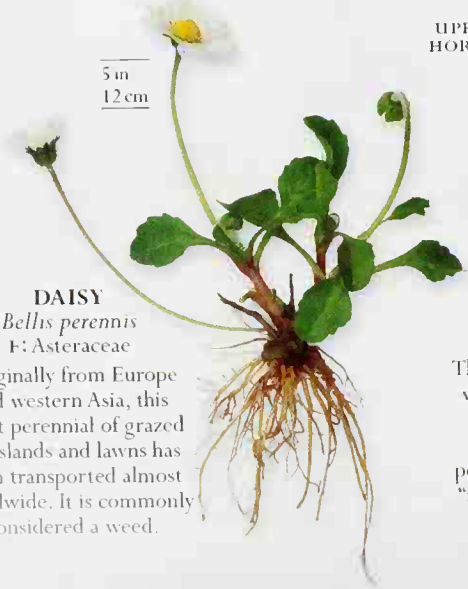
Probably native to southern Europe and western Asia, cornflower seeds were spread with corn, making it an agricultural weed before herbicides.

COMMON RAGWORT
Senecio jacobaea
F: Asteraceae

Toxic to farm animals and avoided by rabbits, this native perennial from Europe and western Asia has invaded grasslands almost worldwide.

OXEYE DAISY
Leucanthemum vulgare
F: Asteraceae

One of the most common white-flowered daisies of Europe and western Asia, this variable patch-forming perennial quickly seeds into disturbed ground.



DAISY
Bellis perennis
F: Asteraceae

Originally from Europe and western Asia, this short perennial of grazed grasslands and lawns has been transported almost worldwide. It is commonly considered a weed.

COMMON DANDELION
Taraxacum officinale
F: Asteraceae

The name for this familiar weed covers an amazing diversity of minutely differing forms, with perhaps 1,000 recognized "microspecies" in Europe and Asia.

PURPLE CONEFLOWER
Echinacea purpurea
F: Asteraceae

Named for its cone-shaped central disk floret, this ornamental perennial from eastern North America is cultivated for herbal remedies against colds and 'flu.

8 ft
2.5 m

MILK THISTLE
Silybum marianum
F: Asteraceae

This weakly spiny biennial, with white-blotched leaves, grows in waste and cultivated ground around S. Europe, N. Africa, and W. Asia.

8 ft
2.5 m

4 ft
1.2 m

GLOBE THISTLE
Echinops bannaticus
F: Asteraceae

Native to grassy places in S.E. Europe and W. Asia, this hairy-stemmed perennial has a spherical head of bluish, tubular "disk" florets.

6½ ft
2 m

SPINY HEAD

GLOBE ARTICHOKE
Cynara cardunculus
F: Asteraceae

A widely grown Mediterranean vegetable, unknown in the wild, this is probably a variety of cardoon, a wasteground perennial in that region.

DEEPLY CUT LEAF

CANADIAN GOLDENROD
Solidago canadensis
F: Asteraceae

Native to N. America but much grown in gardens, this downy perennial has yellow flowerheads borne in curved, spreading flower spikes.

6½ ft
2 m

RHUBARB LIKE LEAF

EARLY SPRING FLOWER

BUTTERBUR
Petasites hybridus
F: Asteraceae

Plants of butterbur have stems with either male or female flowers. It grows in wet meadows and beside streams throughout Europe.

20 in
50 cm

COTTONWEED
Otanthus maritimus
F: Asteraceae

This shrubby perennial grows in coastal habitats in southern Europe, North Africa, and southwest Asia. The common name derives from its woolly stems and leaves.

6 ft
1.8 m

DENSE BLAZING STAR
Liatris spicata
F: Asteraceae

A plant of damp ground in eastern USA, this plant is named after its dense, elongated, spike of rose-purple flowerheads.

5 ft
1.5 m

SPEAR THISTLE
Cirsium vulgare
F: Asteraceae

Common in disturbed ground in Europe and western Asia, this robust perennial with spine-tipped leaves has been spread worldwide by agriculture.

6½ ft/2 m

FRENCH TARRAGON
Artemisia dracunculus
F: Asteraceae

Leaves of this bushy herb from southeast Europe, Asia, and North America are used to flavor fish and other foods.

20 in
50 cm

outer ray florets

24 in
60 cm

YARROW
Achillea millefolium
F: Asteraceae

Found in grassy places throughout Europe and western Asia, this feathery-leaved perennial has been introduced to North America, Australia, and New Zealand.

6½ ft
2 m

BLUE OR LAVENDER FLOWERS

OBLONG ROSETTE LEAF

CHICORY
Cichorium intybus
F: Asteraceae

Introduced almost worldwide from Europe, western Asia, and North Africa, it is cultivated for salad leaves and, from its roots, as a coffee substitute.

leaves hairy on both sides

COTTON LAVENDER
Santolina chamaecyparissus
F: Asteraceae

Widely grown in gardens, this strongly aromatic, dwarf, evergreen shrub with gray-hairy leaves is native to rocky places around the Mediterranean.

24 in
60 cm

20 in
50 cm

GARDEN MARIGOLD
Calendula officinalis
F: Asteraceae

This species has been cultivated so long that its origins are unknown. Marigold extract from the flowers is used to treat skin problems.

20 in
50 cm

GARDEN GAZANIA
Gazania sp.
F: Asteraceae

Seventeen species of *Gazania* grow in southern Africa, most in dry habitats. Cultivars like these can survive in gardens with little watering.

8 in/20 cm

STRAND GAZANIA
Gazania rigens
F: Asteraceae

This sprawling, mat-forming perennial often flowers prolifically on dunes and rocky outcrops along the southern Cape coast of South Africa.

»

4 ft
1.2 m
PERENNIAL LEAF
FLOWER SPIKE

GREAT BLUE LOBELIA
Lobelia siphilitica
F: Campanulaceae
A showy American perennial of woods and meadows from New England to Alabama, this plant was once thought to cure syphilis.

tubular flowers

16 in
40 cm

ROYAL BLUEBELL
Wahlenbergia gloriosa
F: Campanulaceae
The state plant of the Australian Capital Territory, this erect perennial with deep blue flowers grows in mountain grasslands in South Australia.

28 in/70 cm
BELL-SHAPED FLOWER
OVAL LEAVES

BALLOON FLOWER
Platycodon grandiflorum
F: Campanulaceae
The only member of its genus, this Asian perennial with blue or white, bell-shaped flowers also comes in many garden varieties.

5 ft
1.5 m

BUCKBEAN
Menyanthes trifoliata
F: Menyanthaceae
This far-creeping perennial produces its beanlike fruits in bogs and shallow water in North America, Greenland, northern Europe, and Asia.

LANCEOLATE LEAF

CLUSTERED FLOWERHEAD
20 in
50 cm

ROUND-HEADED RAMPION
Phyteuma orbiculare
F: Campanulaceae
With dark blue flowers in rounded heads, this unbranched perennial grows in chalk grasslands from southern England to Greece.

3¼ ft
1 m

NETTLE-LEAVED BELLFLOWER
Campanula trachelium
F: Campanulaceae
Found in fencerows around Europe, Iran, and North Africa, this roughly hairy perennial has nettlelike leaves and blue, bell-shaped flowers.

6 in
15 cm
ONE-SIDED FLOWER
FLESHY LEAF

SWAMPWEED
Selliera radicans
F: Goodeniaceae
This creeping herb is found on coastal sandflats around Chile, Australia, and New Zealand — where it also grows alongside mountain streams.

5 ft
1.5 m

FRINGED WATERLILY
Nymphoides peltata
F: Menyanthaceae
Unlike true water lilies, this aquatic perennial has smaller yellow flowers with five fringed petals. It is found from Europe to Japan.

DIPSACALES

The order Dipsacales is found throughout the world, but especially in the Northern Hemisphere. It is generally characterized by small flowers, often in compact heads, and includes many popular ornamental plants. The valerian family (Valerianaceae) is the most diverse, with around 350 species, but the order also includes the scabious and teasel family (Dipsacaceae), honeysuckle family (Caprifoliaceae), and muskroot family (Adoxaceae).

6 in
15 cm

MUSKROOT
Adoxa moschatellina
F: Adoxaceae
Inflorescences of this delicate woodland perennial from North America, Europe, and Asia have five flowers at right angles (with one facing upward).

32 in
80 cm

RED VALERIAN
Centranthus ruber
F: Valerianaceae
Butterflies appreciate the flowers of this grayish perennial. It is found on coastal rocks and old walls around the Mediterranean and western Asia, and is naturalized elsewhere.

lobed leaves

shiny, red berries

13 ft
4 m

EUROPEAN CRANBERRYBUSH
Viburnum opulus
F: Adoxaceae
Native across Europe to Asia, this deciduous shrub has flattened flowerheads with large, sterile outer flowers, around smaller, fertile ones.

FRUIT

40 ft/12 m
FLOWER

ELDERBERRY
Sambucus nigra
F: Adoxaceae
A shrub or small tree with lobed leaves and flat-topped flowerheads, elderberry grows in Europe, western Asia, and northern Africa.

6½ ft
2 m

GARDEN VALERIAN
Valeriana officinalis
F: Valerianaceae
This perennial is found in grassy places from northern Europe to Japan. It has flattened heads of pale pink, five-petaled flowers, which are darker when in bud.

SCENTED FLOWERS
PERENNIAL LEAVES

sweet-scented flowers

FLOWER STEM

RIPE BERRIES

20 ft
6 m

EUROPEAN HONEYSUCKLE

Lonicera periclymenum
F: Caprifoliaceae

A deciduous shrub of woods and fencerows in Europe and North Africa, honeysuckle scrambles over other plants to reach sunlight before flowering.

oval, pointed leaves

large red bracts surround and protect flowers

6½ ft / 2 m

funnel-shaped flowers attract bees for pollination

HIMALAYAN HONEYSUCKLE

Leycesteria formosa
F: Caprifoliaceae

Originally from the Himalayas and Burma, this deciduous shrub has arching stems and crowded heads of white flowers in reddish purple bracts.

26 ft
8 m

CORAL HONEYSUCKLE

Lonicera sempervirens
F: Caprifoliaceae

This slender vine scrambles high up forest trees in the eastern United States. Its trumpet-shaped red flowers, with yellow interiors, attract hummingbirds for pollination.

10 ft / 3 m

SNOWBERRY

Symphoricarpos albus
F: Caprifoliaceae

Native from Alaska to Colorado, but widely planted elsewhere, this deciduous, suckering shrub has dense heads of pink flowers, ripening to white berries.

13 ft / 4 m

WEIGELA

Weigela florida
F: Caprifoliaceae

Originally from China and Korea, this deciduous shrub has clusters of funnel-shaped flowers that are deep rose in color outside and pale rose inside.

center of flower opens first

spiny, oblong flowerhead

6½ ft
2 m

prickly bracts form cup at base

PERENNIAL LEAF

PRICKLY FLOWER STEM

TEASEL

Dipsacus fullonum
F: Dipsacaceae

This stout biennial of rough ground in Europe, western Asia, and North Africa has prickly stems and leaves, and spiny flower bracts. Seeds are a winter food source for birds.

PINCUSHION-LIKE FLOWER

SPRING FLOWER

SERRATED LEAF

UPRIGHT, OVAL LEAF

30 in
75 cm

FIELD SCABIOUS

Knautia arvensis
F: Dipsacaceae

Flowerheads of this hairy perennial have larger outer petals than inner ones. It grows in dry pastures from Europe to Siberia.

24 in
60 cm

CARMEL DAISY

Scabiosa prolifera
F: Dipsacaceae

The pale yellow flowerheads of this robust eastern Mediterranean annual has large outer, and smaller inner florets. It grows around fields.

3¼ ft
1 m

DEVIL'S-BIT SCABIOUS

Succisa pratensis
F: Dipsacaceae

The devil supposedly bit off the stumpy rootstock of this downy perennial. It grows in damp soils across Europe and North Africa.

FUNGI

Ranging from mushrooms to microscopic molds, fungi were once classified as plants. Today, they are recognized as a distinct kingdom of living things. Growing in or through their food, they digest organic matter, and often become visible only when they reproduce. Fungi are both allies and enemies to other forms of life: vital recyclers and mutually benefiting partners, they also include parasites and pathogens.

» 210

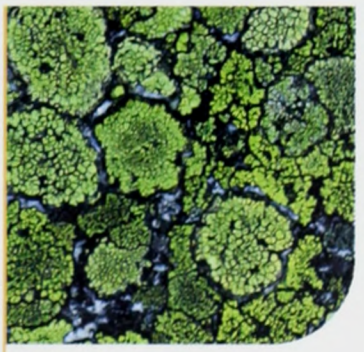
MUSHROOMS

As well as mushrooms, this large group includes bracket fungi, puffballs, and many other species. Their fruitbodies vary in shape, but all make their spores on microscopic cells called basidia.

» 236

SAC FUNGI

These fungi produce their spores in microscopic sacs, which often form a felty layer on their fruitbodies. Many are cup-shaped, but they also include truffles, morels, and single-celled yeasts.



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LICHENS

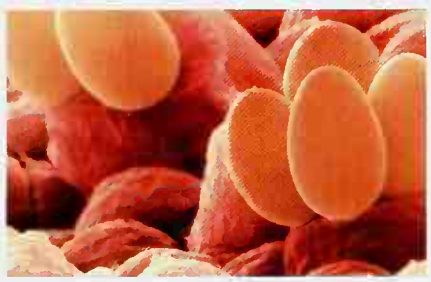
Living partnerships between fungi and algae, lichens colonize all kinds of bare surfaces. Some form flat crusts, while others are like tiny plants. Most grow slowly, and are exceptionally long-lived.

MUSHROOMS

The phylum Basidiomycota includes the majority of what are commonly called mushrooms and toadstools. Found largely in temperate woodland, nearly all share the ability to form sexual spores externally on special cells called basidia.

PHYLUM	BASIDIOMYCOTA
CLASSES	3
ORDERS	52
FAMILIES	177
SPECIES	About 32,000

These typical mushrooms show the cap with radiating gills on the underside, supported by the central stem.



The microscopic spores of the field mushroom are here shown still attached to the basidia, or reproductive cells.

This stinkhorn is covered with a dark spore mass, which rapidly liquifies and emits a foul odor, usually of rotting flesh.

DEBATE

COLORFUL MYSTERY

Many mushrooms have bright colors: red, violet, blue, and green. Scientists have little idea what advantage these colors give to the mushroom. Unlike flowers, they do not need bright colors to attract pollinators. Red and orange pigments possibly prevent damage from sunlight, while others may act as a warning to predators.

Few fungi are as diverse in form as the Basidiomycota. Their fruitbodies (the parts above ground in which spores are produced) have evolved to provide varied and efficient mechanisms for spore dispersal. These fruitbodies often take the form of a stem, cap, and gills, but many are simple, crustlike sheets, and others are more complex, bracketlike forms. More exotic still are the totally enclosed, spherical types such as the puffballs and the earthstars. Then there are the beautiful, coral-like structures of the club and coral fungi, and the often weird, animal-like shapes of the stinkhorns. Each structure supports and produces special spore-producing cells called basidia, and—depending on the fungus concerned—uses a variety of mechanisms to disperse these spores. For example, gilled fungi forcibly eject their spores, to be carried off by air currents. The puffballs, however, depend on a combination of wind and raindrops to puff out their spores. Stinkhorns, on the other hand, use foul odors and bright colors to attract animals, such as insects and other invertebrates, to eat their spore mass and to pass the spores unharmed through their digestive tracts. In this way the spores are scattered as far as the animals travel before excreting them.

FUNGAL FEEDING

The main body of the fungus is usually underground, formed of fine fungal threads called hyphae, which make up a mycelium (fungal body). These threads permeate the substance on which the fungus grows, be it soil, old leaf litter, fallen timber, living plant tissues, or even dead and decaying animals. The mycelium may spread over a large area, and in many fungi it also forms a mutually beneficial relationship with the roots of plants. In this relationship—called a mycorrhiza—the mycelium wraps around and penetrates the plant's roots, providing the fungus with access to carbohydrates from the plant. In return, the plant gains from the mycelium's greater ability to absorb water and mineral nutrients. Other mushrooms break down dead organic matter, or devour living organisms for food—both processes help renew the soil and to improve the growing conditions for other living things.

MUSHROOMS AMONG FALLEN LEAVES >
Many fungi feed on dead and decaying plant tissues and may spread in huge numbers where nutrients and moisture occur.

AGARICALES

Many of the most familiar mushrooms and toadstools belong to this order. They include fungi with fleshy, not woody, fruitbodies (the body supporting the spore-forming cells). Many have caps and stems with gills; some also have pores. Other forms include bird's-nest, brackets, crusts, trufflelike, and puffballs. Most live in leaf litter, soil, or on wood (causing a white rot); others are parasitic or live in association with plant roots (mycorrhizal).

1½–4 in
4–10 cm

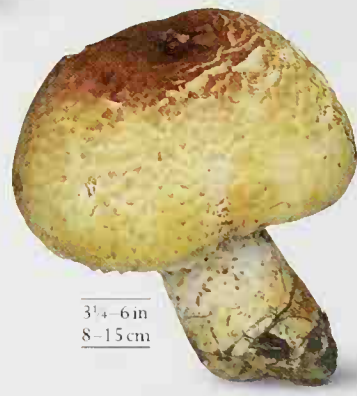
FIELD MUSHROOM
Agaricus campestris
F: Agaricaceae

Common in meadows of North America and Eurasia; this fungus has a rounded cap; bright pink gills turning brown with maturity; and a short stem with a small ring.

2–4 in
5–10 cm

CULTIVATED MUSHROOM
Agaricus bisporus
F: Agaricaceae

Selling in millions, this familiar fungus is common worldwide. Its cap varies from white to dark brown with scales.



3¼–6 in
8–15 cm

THE PRINCE
Agaricus augustus
F: Agaricaceae

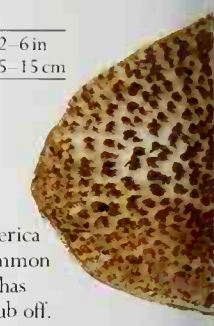
A large, orange-brown, scaly cap and a white, woolly stem with a floppy ring characterize this common species from North America and Eurasia.

2–4¾ in
5–12 cm

1¼–3¼ in
3–8 cm

YELLOW STAINER
Agaricus xanthodermus
F: Agaricaceae

This species has a flattened cap center, chrome-yellow stains on the stem base, and an unpleasant odor. It is common in western North America and Eurasia.



2–6 in
5–15 cm

FRECKLED DAPPERLING
Lepiota aspera
F: Agaricaceae

From woods and gardens in North America and Eurasia; this uncommon fungus's brown cap has pyramidal scales that rub off. The brown stem has a ring.

¾–2¼ in
2–6 cm

2¾–6 in
7–15 cm

HORSE MUSHROOM
Agaricus arvensis
F: Agaricaceae

Common in parks in North America and Eurasia; this species stains dull brassy yellow. The pendent ring on its stem has a cogwheellike pattern on its underside.

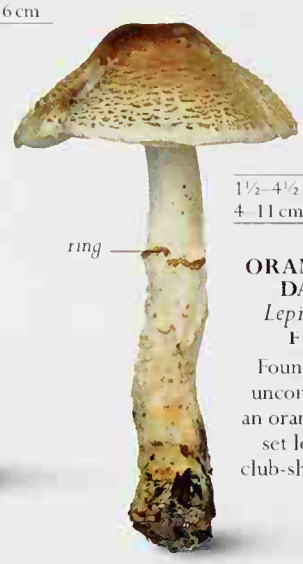
⅜–1½ in
1–4 cm

STINKING DAPPERLING
Lepiota cristata
F: Agaricaceae

A rubberlike smell is a feature of this species of *Lepiota* (most common in woods and meadows) from North America and Eurasia.

LAWYER'S WIG
Coprinus comatus
F: Agaricaceae

This fungus is common in disturbed soils and pathsides in North America and Eurasia. Its tall, shaggy cap is unmistakable, and dissolves into inky fluid.



1½–4½ in
4–11 cm

ORANGE-GIRDLED DAPPERLING
Lepiota ignivolvata
F: Agaricaceae

Found in Eurasia; this uncommon species has an orange-margined ring set low down on the club-shaped, white stem.

2–3¼ in
5–8 cm

WHITE DAPPERLING
Leucoagaricus leucothites
F: Agaricaceae

Common in meadows and grassy roadsides in North America and Eurasia; this fungus's ivory fruitbody turns gray-brown with age. Its gills are white to pale pink.

2–6 in
5–15 cm

SHAGGY PARASOL
Chlorophyllum rhacodes
F: Agaricaceae

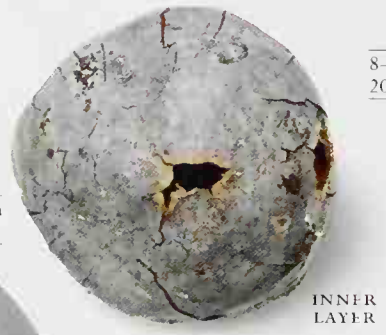
Common in North America and Eurasia; this fungus has a shaggy, brown cap; thick, double-edged ring; reddening flesh; and swollen stem base.

⅜–2 in
1–5 cm

PLANTPOT DAPPERLING
Leucocoprinus birnbaumii
F: Agaricaceae

Common worldwide; this species grows in soils of potted plants. Its features include a delicate golden-yellow cap and a slender stem with a ring.

⅜–1¼ in
1–3 cm



8–20 in
20–50 cm

GRAY PUFFBALL
Bovista plumbea
F: Agaricaceae

This ball-shaped fungus is smooth when young. As it matures, its skin flakes to reveal a papery inner layer. It is common in North America and Eurasia.

GIANT PUFFBALL
Calvatia gigantea
F: Agaricaceae

Common in hedges, fields, and gardens in N. America and Eurasia; this mushroom's large, smooth, white fruitbody with a white to yellow interior is unmistakable.

PARASOL
Macrolepiota procera
F: Agaricaceae

Common in meadows in North America and Eurasia, this tall species has a scaly cap and snakeskin-patterned stem with a thick ring.

¾–1 in
1–2.5 cm

STUMP PUFFBALL
Lycoperdon pyriforme
F: Agaricaceae

Common in North America and Eurasia, this pear-shaped species grows on wood. It has prominent cords at its base, and is firm when young.

¾–1¾ in
2–4.5 cm

MEADOW PUFFBALL
Lycoperdon pratense
F: Agaricaceae

This short-stemmed species has an internal membrane separating the spore-mass from the stem. It is common in meadows throughout Eurasia.

¾–1½ in
2–4 cm

COMMON PUFFBALL
Lycoperdon perlatum
F: Agaricaceae

The most common white puffball, this species is found in North America and Eurasia. Its granular spines rub off to leave circular scars in a regular pattern.

¾–1¾ in
1–3 cm

SPINY PUFFBALL
Lycoperdon echinatum
F: Agaricaceae

This species is found in beech woods in North America and Eurasia. It has groups of long spines that meet at their tips. Its spores are purplish brown.

2–4 in
5–10 cm

PESTLE PUFFBALL
Lycoperdon excipuliforme
F: Agaricaceae

One of the tallest puffballs, this fungus has a buff-white stem that is left behind once the spores are released. It is found in Eurasia.

¾–2 in
2–5 cm

STINKING PUFFBALL
Lycoperdon foetidum
F: Agaricaceae

Common in acidic meadows and woods in Eurasia; this yellowish brown puffball has dark brown spines. Its flesh has an unpleasant smell.

2½–4 in
6–10 cm

WINTER STALKBALL
Tulostoma brumale
F: Agaricaceae

Typically found in sandy soils in dune slacks in North America and Eurasia, this fungus has tiny, whitish yellow, round heads on slender, pale brown stalks.

2½–6 in
6–15 cm

POPLAR FIELDCAP
Agrocybe cylindracea
F: Bolbitiaceae

Found in Eurasia; this rare species grows on poplar wood. The cap cracks when dry and the stem has a ring.

½–1½ in
1–3.5 cm

COMMON FIELDCAP
Agrocybe pediades
F: Bolbitiaceae

Usually found in lawns in Eurasia; this fungus's smooth, yellowish cap and slender stem have a mealy smell and no veil.

1¼–2¾ in
3–7 cm

SPRING FIELDCAP
Agrocybe praecox
F: Bolbitiaceae

Common in North America and Eurasia; during spring, this fungus's cap may have marginal veil fragments. The stem may have a fragile ring.

1¼–2 in
3–5 cm

SANDY STILTBALL
Battarrea diquetii
F: Tulostomataceae

Found in very dry, sandy soils in North America; this tall, stalked species emerges from a leathery "egg." Its brown cap contains the spores.

½–1 in
1–1.5 cm

MILKY CONECAP
Conocybe apala
F: Bolbitiaceae

This species is frequently found in lawns in North America and Eurasia. Its conical, ivory cap with orange-brown gills sits on a tall stem.

½–1¼ in
1–3 cm

YELLOW FIELDCAP
Bolbitius vitellinus
F: Bolbitiaceae

Growing in meadows, this fungus is common in North America and Eurasia; It has a delicate, sticky cap that lasts only a day or so.

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CAESAR'S MUSHROOM
Amanita caesarea
F: Amanitaceae
Found under oaks, mainly from the Mediterranean to central Eurasia; this mushroom has an orange cap and stem, and a white volva.

DEATH CAP
Amanita phalloides
F: Amanitaceae
Common in parts of N. America and Eurasia; this species has a fragile ring, large volva, and sickly smell. Its cap may be greenish, yellowish, or white.

FALSE DEATHCAP
Amanita citrina
F: Amanitaceae
Found in eastern North America and Eurasia; this species has a stem with a distinctly rimmed, rounded bulb, and flesh with a potato odor. Its cap is white or pale yellow.

TAWNY GRISETTE
Amanita fulva
F: Amanitaceae
Common in woods in North America and Eurasia; this fungus may have veil patches. The stem has a white volva (baglike remains of an enclosing veil).

BLUSHER
Amanita rubescens
F: Amanitaceae
This species is common in mixed woods in N. America and Eurasia; Its cap varies from cream to brown, and its flesh bruises pinkish red.

DESTROYING ANGEL
Amanita virosa
F: Amanitaceae
Found throughout northern Eurasia; this rare fungus is pure white with a slightly sticky, bell-shaped cap and a white volva.

PANTHER CAP
Amanita pantherina
F: Amanitaceae
This species has pure white warts (remains of its protective veil), a ring on its stem, and a ridged bulb. It is found in North America and Eurasia.

FLY AGARIC
Amanita muscaria
F: Amanitaceae
Common in North America and Eurasia; this distinctive mushroom is especially common under birches. Its white warts may wash off after rain.

GOLDEN SPINDLES
Clavulinopsis corniculata
F: Clavariaceae
This golden-yellow club with antlerlike branches is relatively common in acidic, unimproved meadows and grassy clearings in woods in Eurasia.

YELLOW CLUB
Clavulinopsis helvola
F: Clavariaceae
Common in grassland in North America and Eurasia; this is one of several yellow clubs. It can only be reliably identified by its spiny spores.

VIOLET CORAL
Clavaria zollingeri
F: Clavariaceae
A rare species found in mossy meadows and woodlands in North America and Eurasia; this species has violet, coral-like branches.

WHITE SPINDLES
Clavaria fragilis
F: Clavariaceae
This fungus forms dense clusters of pure white, simple clubs in woods and meadows in Eurasia.

WOOD PINKGILL
Entoloma rhodopolium
F: Entolomataceae
Found in Eurasia; this pale gray to gray-brown species has a cap with a domed center and slender stem. It may smell of bleach.

MOUSEPEE PINKGILL
Entoloma incanum
F: Entolomataceae
Smelling of mice, this pinkgill has a hollow stem and a bright grass-green cap that fades to brown with age. It grows in unimproved meadows in Eurasia.

BLUE EDGE PINKGILL
Entoloma serrulatum
F: Entolomataceae
This blue-black capped fungus has serrated pinkish gills with dark edges. It is found in meadows and parks in N. America and Eurasia.

LILAC PINKGILL
Entoloma porphyrophaeum
F: Entolomataceae
Occasionally found in meadows, this fungus grows in Eurasia. It has a gray-purple fibrous cap and stem, and pinkish gills.

THE MILLER
Clitopilus prunulus
F: Entolomataceae
Common in mixed woods in North America and Eurasia; this fungus has a cap that changes shape with age, starting convex then becoming depressed.

2–8 in
5–20 cm

contrasting cream gills

WOOD BLEWIT
Lepista nuda
F: Tricholomataceae

Common in mixed woods in North America and Eurasia, this species has a violet cap that fades to brown, but the stem and gills remain violet.

2–8 in
5–20 cm

BLUE LEGS
Lepista personata
F: Tricholomataceae

The blue legs has a buff cap and a bright blue-lilac stem with perfumed flesh. It is common in open meadows in Eurasia.

3¼–8 in
8–20 cm

CLOUDED FUNNEL
Clitocybe nebularis
F: Tricholomataceae

This fleshy mushroom has crowded gills that often run down the stem. It frequently grows in large circles in North America and Eurasia.

1¼–2¾ in
3–6 cm

ANISEED FUNNEL
Clitocybe odora
F: Tricholomataceae

Common in North America and Eurasia, this fungus is unmistakable due to its strong aniseed odor. Its sea-green color fades as it matures to grayish green.

¾–2¾ in
2–6 cm

IVORY FUNNEL
Clitocybe dealbata
F: Tricholomataceae

This species grows in rings in lawns and meadows in North America and Eurasia. It has a frosted appearance and slightly decurrent gills.

¾–3¼ in
2–8 cm

SULPHUR KNIGHT
Tricholoma sulphureum
F: Tricholomataceae

Characterized by its bright sulphur-yellow color and repulsive smell of coal gas, this fungus is common in parts of North America and mixed woods in Eurasia.

2–10 in/5–25 cm

PIPE CLUB
Macrotyphula fistulosa
F: Typhulaceae

Often found in large groups in parts of North America and in Eurasia, this species has tall, slender clubs attached to fallen branches and hardwood litter.

decurrent gills (running down stem)

inrolled cap (curls inward at margin)

4¾–16 in
12–40 cm

short stem

GIANT FUNNEL
Leucopaxillus giganteus
F: Tricholomataceae

Often found in huge rings in North America and Eurasia, this giant fungus is white, with decurrent gills, an inrolled cap margin, and a short stem.

2–4¾ in
5–12 cm

DINGY AGARIC
Tricholoma portentosum
F: Tricholomataceae

Usually found with conifers in northern North America and northern Eurasia, this species has a smooth, bell-shaped cap and a stout, whitish stem that flushes yellowish.

1½–4 in
4–10 cm

SOAPY KNIGHT
Tricholoma saponaceum
F: Tricholomataceae

Variable in color—gray-brown, greenish or pinkish gray to mottled—with a soapy smell, this species is common in mixed woods in North America and Eurasia.

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FLY AGARIC

Amanita muscaria

The fly agaric is arguably the most famous of all fungi, and it appears in illustrations in children's books all over the world. The bright scarlet cap, usually scattered with white spots of veil tissue, make it one of the easiest fungi to identify. Found originally throughout most of Europe, northern Asia, and North America, it now grows wherever humans have planted the host trees—usually birch—with which the fungus forms a mutually beneficial relationship. It is now commonly found in parts of Africa, India, and Australasia. All parts of the fly agaric are poisonous, although rarely fatal.

SIZE Cap diameter 2¼–6 in (6–15 cm)
HABITAT Birch and pine woods
DISTRIBUTION Almost worldwide
SPORE COLOR White

large floppy ring is easily torn

< FAMILIAR FUNGUS
The fly agaric changes shape dramatically as it grows and expands, but the color and key characters usually remain constant. The cap may fade to yellow if there has been persistent rain. Its common name refers to an old folk remedy—the red skin of the cap was used in a saucer of milk to poison annoying house flies.

v SLICE THROUGH CAP
In cross section, the yellowish orange flesh immediately beneath the red skin of the cap is revealed. The gills, or lamellae, are bright white, in contrast.

v SCALES
The white or pale yellow warty scales are all that remain of an enveloping veil of tissue that once enclosed the young cap.

STEM BASE >
The base is swollen and clublike, with warty ridges encircling the upper part of the bulb. Threads of mycelium (fungal tissue) connect to fine tree roots below the soil.

^ GILLS
The fly agaric's radiating gills are of different lengths, some stopping well short of the stem. This allows them to fill the available space, ensuring that spore production is maximized.

GROWTH STAGES OF A FLY AGARIC

^ BABY BUTTON
The young button is completely enclosed in a warty universal veil.

^ BROKEN VEIL
The stem has started to grow, and the universal veil on the cap has split apart.

^ GROWING CAP
The cap expands, with the partial veil still attached underneath.

^ GILLS APPEAR
The partial veil starts to tear, forming the ring and exposing the gills above.

^ SPORE DISPERSAL
Spores grow on the exposed gills and are then released into the air.

^ OLD AGE
At the end of its life the cap coloration fades and the cap may turn upward.

2–4¾ in
5–12 cm

THE GYPSY
Cortinarius caperatus
F: Cortinariaceae

From North America and northern Eurasia; this species, found in conifer woods, has a frosted cap with a white veil and a stem with a distinct sheathing ring.

1¼–2¼ in
3–6 cm

DAPPLED WEBCAP
Cortinarius bolaris
F: Cortinariaceae

Common in beech woods in Eurasia; this fungus has tiny reddish brown scales on its cap and stem. The flesh stains yellow-orange in the stem.

2–3¼ in
5–8 cm

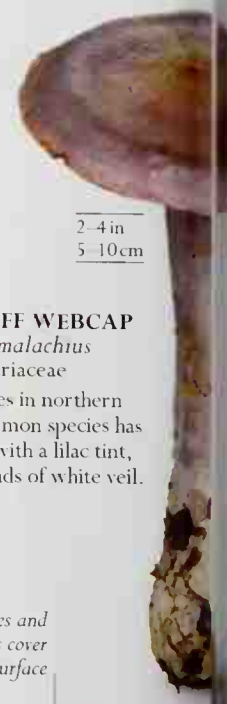
PEARLY WEBCAP
Cortinarius alboviolaceus
F: Cortinariaceae

This species is common in mixed woods in North America and Eurasia. Its silvery white fruitbody has a lilac tint. The gills mature to cinnamon-brown.

2¼–4 in
6–10 cm

ELEGANT WEBCAP
Cortinarius elegantissimus
F: Cortinariaceae

Found throughout Eurasia in beech woods in chalky soil; this fungus has a vivid orange-yellow cap and a yellow stem with a large, marginate bulb.



2–4 in
5–10 cm

BLUE AND BUFF WEBCAP
Cortinarius malachius
F: Cortinariaceae

Found under pines in northern Eurasia; this uncommon species has a pale brown cap with a lilac tint, and a stem with bands of white veil.

1¼–3¼ in
3–8 cm

SCALY WEBCAP
Cortinarius pholideus
F: Cortinariaceae

This uncommon species is found under birches in Eurasia. It is easily recognized by its scaly, brown cap and stem, and violet gills and stem apex when young.

2¼–4 in
6–10 cm

ORANGE WEBCAP
Cortinarius mucosus
F: Cortinariaceae

Restricted to North America and northern Eurasia; this species is common in pine woods. Its orange-brown cap and stout, white stem are very slimy. The gills are rust-brown.

2–4¾ in
5–12 cm

RED BANDED WEBCAP
Cortinarius armillatus
F: Cortinariaceae

The cinnabar-red bands of veil on the club-shaped stem distinguish this common species of birch woods in North America and Eurasia.

1¼–2¾ in
3–7 cm

SPLENDID WEBCAP
Cortinarius splendens
F: Cortinariaceae

This rare species has a golden-yellow cap, yellow flesh, a sulphur-yellow veil, and a bulbous stem. It mainly occurs in beech woods in Eurasia.

⅜–1¼ in
1–3 cm

1½–4 in
4–10 cm

BITTER BIGFOOT WEBCAP
Cortinarius sodagnitus
F: Cortinariaceae

Found mainly in southern England and Mediterranean Eurasia; this uncommon species occurs in beech woods on chalky soil. The bulb on the stem is large.

PIXIE WEBCAP
Cortinarius flexipes
F: Cortinariaceae

An odor of pelargoniums and delicate white hairs on the pointed cap characterize this species. It is common under birches in North America and northern Eurasia.

2¼–6 in
6–15 cm

VIOLET WEBCAP
Cortinarius violaceus
F: Cortinariaceae

Found in mixed woodland throughout North America and Eurasia; this rare species has a distinctive intensely violet-colored cap and stem.

3¼–6 in
8–15 cm

BIRCH WEBCAP
Cortinarius triumphans
F: Cortinariaceae

Common under birches in Eurasia; this fungus is yellow-orange overall, with prominent girdles of yellow veil on the stem.

CAP (UPPER SIDE)

CAP (UNDERSIDE)

¼–2¾ in
2–7 cm

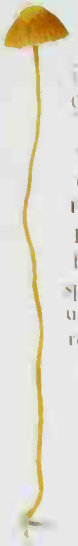
PEELING OYSTERLING
Crepidotus mollis
F: Crepidotaceae

This fungus occurs in North America and Eurasia. Its small, fan-shaped, pale cap has a gelatinous skin, which peels easily. The stem is absent or very short.

VARIABLE OYSTERLING
Crepidotus variabilis
F: Crepidotaceae

One of several similar species in North America and Eurasia; its cap is dry with fine fibers. It usually lacks a stem.

3/16–1¾ in
0.5–3 cm



⅛–⅜ in
0.3–0.8 cm

TINY PIXIE CAP
Galerina calyptrata
F: Hymenogastraceae

Found in Eurasia; this fungus is one of many species only identifiable under a microscope. Its rounded cap is orange-brown and striated.

red band

STAR FIBERCAP
Inocybe asterospora
F: Inocybaceae

A flattened bulb at the stem's base and star-shaped spores distinguish this small, brown fibrous-capped species from Eurasia.

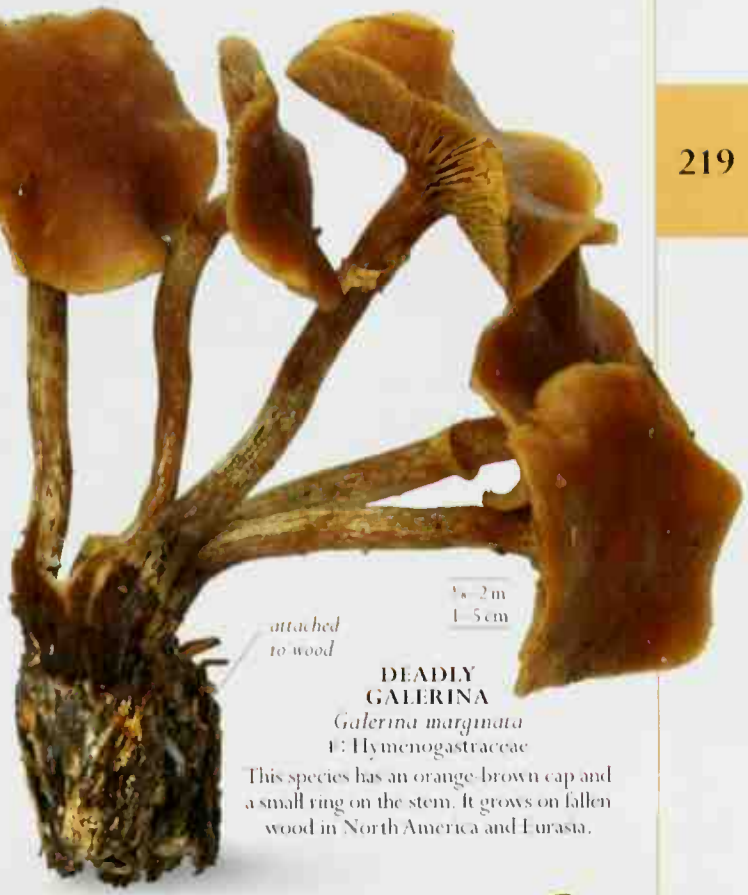
1⅛–2¾ in
3–7 cm

CAP NOT FULLY EXPANDED

2–4¾ in
5–12 cm

ROOTING POISONPIE
Hebeloma radicosum
F: Hymenogastraceae

The deeply rooting stem with a large ring, buff cap with flat scales, and strong smell of marzipan characterize this Eurasian species.



attached to wood

⅛–2 in
1–5 cm

DEADLY GALERINA
Galerina marginata
F: Hymenogastraceae

This species has an orange-brown cap and a small ring on the stem. It grows on fallen wood in North America and Eurasia.

1½–3½ in
4–9 cm

POISONPIE
Hebeloma crustuliniforme
F: Hymenogastraceae

From North America and Eurasia; this species smells strongly of radish. Its cap is ivory-white to buff, and slimy when wet. In damp weather, the gills exude droplets.

1¼–2¾ in
3–7 cm

SPLIT FIBERCAP
Inocybe rimosa
F: Inocybaceae

Common in mixed woodland in North America and Eurasia; its pointed fibrous cap is straw-yellow and the stem is tall and slender.

radial fibers

stout stem

1¼–3½ in
3–9 cm

DEADLY FIBERCAP
Inocybe erubescens
F: Inocybaceae

Found in mixed woodland in chalk in Eurasia; this uncommon species has a fibrous cap that discolors with age, and stout stem that bruises red.

⅜–1½ in
1–4 cm

WHITE FORM

VIOLET FORM

WHITE FIBERCAP
Inocybe geophylla
F: Inocybaceae

This is one of the most common *Inocybe* species in woods in North America and Eurasia; It has a conical, silky cap and a slender stem.

⅜–1¾ in
1–4.5 cm

TORN FIBERCAP
Inocybe lacera
F: Inocybaceae

Found in North America and Eurasia; this is distinguished by its cylindrical spores. It has a scaly fibrous cap and a slender brown stem.

5/16–1½ in
0.8–4 cm

LILAC LEG FIBERCAP
Inocybe griseolilacina
F: Inocybaceae

A common species in beech woods in Eurasia; it has a scaly cap and a pale violet, slender stem.

»

SCARLET WAXCAP
Hygrocybe coccinea
F: Hygrophoraceae
The scarlet, waxy cap, gills, and stem make this a very striking fungus of unimproved grasslands in North America and Eurasia.

SNOWY WAXCAP
Hygrocybe virginea
F: Hygrophoraceae
The most common waxcap in all types of grassland in Eurasia; its waxy cap and slender stem are translucent. It has decurrent gills.

PARROT WAXCAP
Hygrocybe psittacina
F: Hygrophoraceae
This fungus occurs in North America and Eurasia; its slimy cap is vivid green to orange and the upper part of the stem is bright green.

PINK WAXCAP
Hygrocybe calyptriformis
F: Hygrophoraceae
This highly recognizable but rare fungus has a pointed pink cap, fragile pale stem, and waxy gills. Found in Eurasia, it grows in unimproved meadows.

BLACKENING WAXCAP
Hygrocybe conica
F: Hygrophoraceae
Very common in grasslands and woodlands in N. America and Eurasia; this species has a conical reddish orange cap and fibrous stem that blacken with age or bruising.

MEADOW WAXCAP
Hygrocybe pratensis
F: Hygrophoraceae
This is one of the larger meadow-occurring waxcaps, and is found in North America and Eurasia. It has a stout stem and a fleshy cap with gills running down the stem.

CRIMSON WAXCAP
Hygrocybe punicea
F: Hygrophoraceae
Found in unimproved grassland in North America and Eurasia; this uncommon species is the largest blood-red waxcap. Its stem is dry and fibrous with a white base.

CLUB FOOT
Ampulloclitocybe clavipes
F: Hygrophoraceae
Common in mixed woods in late fall, this species from North America and Eurasia has decurrent gills and a swollen, spongy base.

GOLDEN WAXCAP
Hygrocybe chlorophana
F: Hygrophoraceae
Found in Eurasia; this is the most common waxcap found in meadows. It has a bright yellow-orange, slightly sticky cap.

AMETHYST DECEIVER
Laccaria amethystina
F: Hydnangiaceae
This highly recognizable, slender fungus from North America and Eurasia has an intense violet coloration when fresh, and powdery spores dusting the gills.

DECEIVER
Laccaria laccata
F: Hydnangiaceae
Variable color—from brick-red to flesh-pink—with a dry cap and thick gills; this species is abundant in temperate woods in North America and Eurasia.

CONIFERCONE CAP
Baeospora myosura
F: Cyphellaceae
Found in North America and Eurasia; this is one of a few fungi growing mostly on pinecones. It has crowded, narrow gills and a velvety stem.

IVORY WOODWAX
Hygrophorus eburneus
F: Hygrophoraceae
This species is found in beech woods in North America and Eurasia; it has a sticky cap and stem, thick gills, and a flowery smell.

HERALD OF WINTER
Hygrophorus hypothejus
F: Hygrophoraceae
Appearing in pine woods after a frost in North America and Eurasia; this sticky fungus has an olive-brown cap and yellow stem.

cap frequently splits as it ages

½–1½ in
1–4 cm

½–1½ in
0.5–1.5 cm

1½–4½ in
4–12 cm

ST. GEORGE'S MUSHROOM
Calocybe gambosa
F: Lyophyllaceae

This ivory-buff species from Eurasia often grows in fairy rings at woodland margins in late spring. The mushroom smells strongly of newly ground meal.

PINK DOMECAP
Calocybe carnea
F: Lyophyllaceae

This species grows in short grass in North America and Eurasia; its smooth cap and fibrous stem are rose pink and the gills are white.

2–4 in
5–10 cm

SILKY PIGGYBACK
Asterophora parasitica
F: Lyophyllaceae

One of two well-known parasitic species to live on rotten fruitbodies of brittle-caps, this fungus from N. America and Eurasia has a rounded silky cap.

CLUSTERED DOMECAP
Lyophyllum decastes
F: Lyophyllaceae

Common on roadsides, pathsides, and disturbed soil in North America and Eurasia; this fungus forms clumps of tough caps with stout stems.

HORSEHAIR PARACHUTE
Marasmius androsaceus
F: Marasmiaceae

Found in Eurasia, this fungus has a distinctive black hairlike stem, while its radially grooved cap is pale pinkish brown.

½–1½ in
0.5–1 cm

cap depressed at center

radial groove

½–2 in
1–5 cm

½–1½ in
0.5–1.5 cm

HAIRY PARACHUTE
Crinipellis scabella
F: Marasmiaceae

Found on dead stems of grasses, this recognizable fungus is from Eurasia. It has a small cap and a long, slender stem covered with dense, bristling brown hair.

FAIRY RING CHAMPIGNON
Marasmius oreades
F: Marasmiaceae

This classic fairy-ring mushroom is common in open grass in North America and Eurasia; it has fleshy, beige caps with thick gills.

½–¾ in
0.5–2 cm

wiry stem

1½–3½ in
1.5–4 cm

GARLIC PARACHUTE
Marasmius alliaceus
F: Marasmiaceae

This species grows in beech woods in Eurasia; it has a tall, slender, blackish stem and a strong odor of rancid garlic.

COLLARED PARACHUTE
Marasmius rotula
F: Marasmiaceae

Like little parachutes, this mushroom's rounded, depressed caps are radially grooved. Its tough stems are attached to woody debris. It occurs in North America and Eurasia.

COMMON BIRD'S NEST
Crucibulum laeve
F: Nidulariaceae

Forming minature nests with spore-filled, egglike cases, this common species may be hard to spot in woody debris. It occurs in North America and Eurasia.

½–¾ in
0.5–1 cm

FLUTED BIRD'S NEST
Cyathus striatus
F: Nidulariaceae

This fungus is recognized by its hairy, brown, and tall fluted nests containing 10–15 egglike cases. It occurs in woody debris across North America and Eurasia, but is not common.

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SILVERLEAF FUNGUS
Chondrostereum purpureum
F: Cyphellaceae
Common on cherry and plum trees, it is found in North America and Eurasia. Violet below when young, it darkens to purple-brown with age.

¾–2 in
2–5 cm

wavy margin

purple underside

⅛–⅜ in
0.3–1 cm

ORANGE BONNET
Mycena acicula
F: Mycenaceae
Common in leaf litter and debris in broadleaf woods in North America and Eurasia; this fungus has a tiny, translucent cap that is striped almost to the center.

3/16–1 in
0.5–2.5 cm

YELLOWLEG BONNET
Mycena epipterygia
F: Mycenaceae
Occurring in North America and Eurasia; this fungus grows in acidic soils in woods and meadows. Its cap and stem have a sticky, peelable layer.

⅜–1½ in
1–4 cm

CLUSTERED BONNET
Mycena inclinata
F: Mycenaceae
Found in dense clusters on wood in North America and Eurasia; this fungus has a cap with toothed margins and a strong soapy smell.

⅜–1¼ in
1–3 cm

SAFFRONDROP BONNET
Mycena crocata
F: Mycenaceae
Common in woods with chalky soils in Eurasia; this species exudes a bright saffron-orange juice when it is broken.

⅜–2¼ in
1–6 cm

COMMON BONNET
Mycena galericulata
F: Mycenaceae
Abundant in temperate woods in North America and Eurasia; this fungus is variable in color. Its pinkish gray gills have linking veins and cross-ridges.

1¼–2¼ in
3–6 cm

BLACKEDGE BONNET
Mycena pelianthina
F: Mycenaceae
Found in Eurasia; this fungus is characterized by a strong smell of radish. It has purplish black-edged gills and a pale lilac to gray-brown cap.

domed cap center

ROSY BONNET
Mycena rosea
F: Mycenaceae
Found in beech woods in Eurasia; this common species has a robust pink cap and stem, and smells strongly of radish.

¾–2¼ in
2–6 cm

OLIVE OYSTERLING
Panellus serotinus
F: Mycenaceae
From North America and Eurasia; this mushroom fruits in winter, often near water on hardwood tree trunks. Its cap is slimy when wet.

1¼–4 in
3–10 cm

club-shaped stem

1½–3¼ in
4–8 cm

SPINDLE TOUGHSHANK
Gymnopus fusipes
F: Omphalotaceae
Abundant in Eurasian oak woods from early summer onward; this fungus forms large clumps of tough fruitbodies on tree roots.

1–2¼ in
2.5–6 cm

WOOD WOOLLYFOOT
Gymnopus peronatus
F: Omphalotaceae
The common name of this species from Eurasia refers to the stiff, fuzzy hairs at the base of the stem.

1½–4 in
4–10 cm

SPOTTED TOUGHSHANK
Rhodocollybia maculata
F: Omphalotaceae
Common in mixed woods across North America and Eurasia; this fungus has a white cap, stem, and gills. The crowded gills stain rust-red with age.

1¼–2¼ in
3–6 cm

BUTTER CAP
Rhodocollybia butyracea
F: Omphalotaceae
This fungus is abundant in woods in North America and Eurasia. Varying from blackish or reddish brown to dark ocher, its cap is oily to the touch.

2–6 in
5–15 cm

JACK O'LANTERN
Omphalotus illudens
F: Omphalotaceae
Found across North America and Eurasia; this bright orange, poisonous fungus is famous for gills that glow in the dark with an eerie greenish light.

1¼–4 in
3–10 cm

HONEY FUNGUS
Armillaria gallica
F: Physalacriaceae
Found in woods across Eurasia; this species is usually found on the ground. It is a weak parasite on the trees around which it grows.

1–4 in
2.5–10 cm

WRINKLED PEACH
Rhodotus palmatus
F: Physalacriaceae
Found on fallen logs of mainly elm, this uncommon species of North America and Eurasia has an unusual, peach-pink, wrinkled cap and a fruity odor.

¾–2½ in
1–6 cm

VELVET SHANK
Flammulina velutipes
F: Physalacriaceae
Growing throughout winter in North America and Eurasia, this fungus is characterized by its often sticky cap and velvety stem.

¾–6 in
2–15 cm

PORCELAIN FUNGUS
Oudemansiella mucida
F: Physalacriaceae
Usually found on beech logs in Eurasia; this fungus has gray-white caps that are slimy when wet. The tough stem has a thin ring.

1–4 in
2.5–10 cm

ROOTING SHANK
Xerula radicata
F: Physalacriaceae
Found across North America and Eurasia; this deep-rooted fungus has a stiff, tall stem. The cap is slimy when wet, and the gills are widely spaced.

BRANCHING OYSTER
Pleurotus cornucopiae
F: Pleurotaceae
Growing in clusters on fallen logs, usually of elm, this fungus has trumpet-shaped caps with gills running down the short, frequently branching stems. It occurs in North America and Eurasia.

1½–4½ in
4–12 cm

caps often overlap

2½–8 in
6–20 cm

OYSTER MUSHROOM
Pleurotus ostreatus
F: Pleurotaceae
From North America and Eurasia; this species is found on trees and logs. Its shelflike caps vary from blue-green to pale buff. The stem is almost absent.

white veil breaks into patches

tiny glistening granules

¾–1½ in
2–3 cm

GLISTENING INKCAP
Coprinellus micaceus
F: Psathyrellaceae
Usually found in clusters, this mushroom's rounded, grooved caps are dusted with micalike flakes of veil. It is common on wood in North America and Eurasia.

¼–¾ in
0.5–1 cm

FAIRIES' BONNETS
Coprinellus disseminatus
F: Psathyrellaceae
Often found in clusters on rotted stumps in North America and Eurasia; it has tiny umbrella-like caps with deeply fluted grooves. The gills are blackish when mature.

1–3 in
2.5–7.5 cm

WEEPING WIDOW
Lacrymaria lacrymabunda
F: Psathyrellaceae
Common on pathsides and disturbed soil in North America and Eurasia; it is named for its black gills that weep droplets from their edges.

¾–2¼ in
1.5–7 cm

PALE BRITTLESTEM
Psathyrella candolleana
F: Psathyrellaceae
Usually found in clusters in woody debris in early summer, it has fragile, slender stems and pale or buff caps. It occurs in North America and Eurasia.

⅜–1½ in
0.8–4 cm

CLUSTERED BRITTLESTEM
Psathyrella multipedata
F: Psathyrellaceae
The densely clustered stems of this species are joined at the base. It is usually found in open grass across Eurasia.

1–3¼ in
2.5–8 cm

COMMON INKCAP
Coprinopsis atramentaria
F: Psathyrellaceae
Occurring in North America and Eurasia, this species has egg-shaped caps that dissolve to a blackish fluid as the spores are released.

2–3¼ in
5–8 cm

MAGPIE INKCAP
Coprinopsis picacea
F: Psathyrellaceae
Found on chalky soils in Eurasian woodlands; this uncommon species has white, fluffy scales that contrast with the dark gray-brown cap.

»

1½–4 in
4–10 cm

DEER SHIELD
Pluteus cervinus
F: Pluteaceae
Found in North America and Eurasia; this species is variable in color, with a radially fibrous cap, often dome-centered; pink gills not attached to the stem; and a fibrous stem.

⅜–2¼ in
1–6 cm

YELLOW SHIELD
Pluteus chrysophaeus
F: Pluteaceae
A golden to greenish yellow cap, yellow gills turning pink, and a whitish stem characterize this species. Found in Eurasia, it grows on decayed wood.

1–3¼ in
2.5–8 cm

WILLOW SHIELD
Pluteus salicinus
F: Pluteaceae
Common in broad-leafed woodlands in Eurasia; this species can be identified by the bluish gray staining at the base of its slender stem.

4–10 in
10–25 cm

BEEFSTEAK FUNGUS
Fistulina hepatica
F: Schizophyllaceae
Resembling a fleshy steak, with bloodlike red juice, it is particularly common in warmer parts of North America and Eurasia.

fine silky-hairy surface

SILKY ROSEGILL
Volvariella bombycina
F: Pluteaceae
4–10 in
10–25 cm
Growing on deciduous trees in North America and Eurasia; this rare species has a white to pale lemon cap and a whitish stem with a baglike thin veil enclosing the base of the stem.

⅜–2 in
1–5 cm

CAP
(UPPER SIDE)

CAP (UNDERSIDE)

COMMON PORECRUST
Schizophyllum commune
F: Schizophyllaceae
Found in North America and Eurasia; this fan-shaped fungus is identified by the gill-like spore surface on the underside of the cap.

greenish yellow gills

orange cap center

2¾–5½ in
6–14 cm

STUBBLE ROSEGILL
Volvariella gloiocephala
F: Pluteaceae
Quite common in fields and old stubble, and in wood chip mulch, in North America and Eurasia; this species has a sticky, gray cap.

1¼–2¾ in
3–7 cm

CONIFER TUFT
Hypholoma capnoides
F: Strophariaceae
Found in North America and Eurasia; this uncommon species occurs on conifer wood. Its whitish gills mature to grayish lilac.

1¼–2¾ in
3–7 cm

SULPHUR TUFT
Hypholoma fasciculare
F: Strophariaceae
Abundant in temperate woods in North America and Eurasia; this species has greenish yellow gills that mature to dark purple, and are easy to recognize in the field.

2–4 in
5–10 cm

BRICK TUFT
Hypholoma sublateritium
F: Strophariaceae
This species is characterized by a fleshy cap with veil fragments and pale yellow gills that mature to lavender. It grows on hardwoods in North America and Eurasia.

SHEATHED WOODTUFT
Kuehneromyces mutabilis
F: Strophariaceae

Often confused with the deadly *Galerina marginata*, this species can be identified by its sticky cap, scaly stem, and brown gills. It occurs in North America and Eurasia.

REDLEAD ROUNDHEAD
Leratiomyces ceres
F: Strophariaceae

Previously known as *Stropharia aurantiaca*, this species has a bright red cap and reddish flushed stem. It grows among wood chips in North America and Eurasia.

ALDER SCALYCAP
Pholiota alnicola
F: Strophariaceae

Found in Eurasia, this species is characterized by a sticky cap and tufted habit. Despite its common name, it is usually seen at the base of birches.

GOLDEN SCALYCAP
Pholiota aurivella
F: Strophariaceae

This fairly common species is found on beech logs or trunks in North America and Eurasia. Its sticky golden caps have dark orange-brown scales.

DUNG ROUNDHEAD
Stropharia semiglobata
F: Strophariaceae

Occurring in animal dung or in grass where animals graze, it is found in North America and Eurasia. It has a sticky cap and a slender stem with a ring.

SHAGGY SCALYCAP
Pholiota squarrosa
F: Strophariaceae

Growing in North America and Eurasia, this fungus has a distinctive dry, sharply scaly cap and stem; pale yellow gills; and a smell of corn or radish.

LIBERTY CAP
Psilocybe semilanceata
F: Strophariaceae

This well-known agaric has a conical, dull yellow cap with a distinct point. Common in meadows in late fall, it occurs in North America and Eurasia.

BLUE-GREEN SLIMEHEAD
Stropharia cyanea
F: Strophariaceae

This fungus has a blue-green cap that fades to yellow. It is found in North America and Eurasia.

WHITELACED SHANK
Megacollybia platyphylla
F: Incertae sedis

Found in North America and Eurasia, this species has a radially fibrous, pale gray-brown cap; widely spaced, deep gills; and a stem base with rootlike strands.

COMMON CAVALIER
Melanoleuca polioleuca
F: Incertae sedis

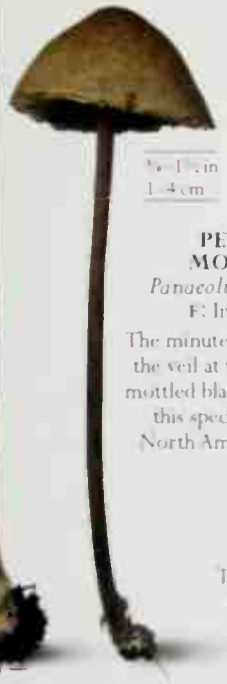
Common in grass in Eurasia; this species has a gray-brown cap with white gills. Its stem has blackish flesh at the base.

PLUMS AND CUSTARD
Tricholomopsis rutilans
F: Incertae sedis

Common on pine stumps, this species has a reddish purple cap and stem, and golden-yellow gills. It grows in North America and Eurasia.

SPECTACULAR RUSTGILL
Gymnopilus junonius
F: Incertae sedis

Occurring in Eurasia, this fungus is found in clumps, usually at the base of a tree. It has a dry cap with crowded, shallow yellowish gills.



PETTICOAT MOTTLEGILL
Panaeolus papilionaceus
F: Incertae sedis

The minute toothed remains of the veil at the cap margin and mottled black gills characterize this species. It is found in North America and Eurasia.

GOBLET
Pseudoclitocybe cyathiformis
F: Incertae sedis

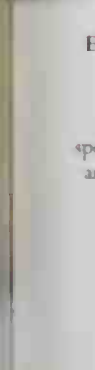
This distinctive species has a very dark coloration and a tall, fibrous stem. Found in Eurasia, it is common in late fall and winter.

CINNABAR POWDERCAP
Cystodermella cinnabarina
F: Incertae sedis

Found in North America and Eurasia, this species has a brick-red cap and pale cream gills. The cap and stem have a granular surface.

TROOPING FUNNEL
Infundibulicybe geotropa
F: Incertae sedis

This fungus has a funnel-shaped, fleshy cap; a tall stem; and a pale leather-brown color. It occurs in Eurasia.



EGGHEAD MOTTLEGILL
Panaeolus semiovatus
F: Incertae sedis

Found in animal dung, this species occurs in North America and Eurasia; it is characterized by a sticky gray cap and a ring around its tall stem.

BOLETALES

This order contains fleshy fungi and includes those with both pored and gilled fruitbodies, most with cap and stem, but some are crusts, puffballs, or trufflelike. The majority live in association with trees (mycorrhizal), but some feed on dead wood and cause a brown rot, while others are parasitic. The spore-producing layer—the hymenium—is easily loosened from the flesh.

BAY BOLETE
Boletus badius
F: Boletaceae

A common species found among conifers or beech trees in North America and Eurasia; its color varies from orange-brown to bay.

BITTER BEECH BOLETE
Boletus calopus
F: Boletaceae

From western North America and Eurasia; its cap varies from white to buff. Its yellow pores and cream flesh bruise blue.

SUMMER BOLETE
Boletus reticulatus
F: Boletaceae

A cracking, matte, brown cap and a stem with a fine white net extending to its base distinguish this species from eastern North America and Eurasia.

PENNY BUN
Boletus edulis
F: Boletaceae

Found worldwide; this species is identified by the fine white markings on its stem, the unchanging cream flesh, and the white pores that mature to yellow.

PARASITIC BOLETE
Boletus parasiticus
F: Boletaceae

This small mushroom from North America and Eurasia grows only on the common earthball, causing its host to become hollow.

PEPPERY BOLETE
Chalciporus piperatus
F: Boletaceae

Common under conifers and also with fly agaric under birches in North America and Eurasia; it has cinnamon pores and yellow flesh.

BITTER BOLETE
Tylopilus felleus
F: Boletaceae

This species is found in North America and Eurasia; characterized by pores that turn pink with age and a strongly netted stem.

OLD MAN OF THE WOODS
Strobilomyces strobilaceus
F: Boletaceae

Found in North America and Eurasia; this rare species is unmistakable with black woolly scales on its cap and stem, and white tubes.

3¼–6 in
8–15 cm

ORANGE BIRCH BOLETE
Leccinum versipelle
F: Boletaceae

Found in Eurasia, this species has a yellow-orange fleshy cap. The stem has black, woolly flecks and the flesh stains lilac-black.

2¼–6 in
6–15 cm

BROWN BIRCH BOLETE
Leccinum scabrum
F: Boletaceae

One of many similar species, this fungus is from North America and Eurasia. Its flesh may flush pink when cut, and the cap is sticky when wet.

½–1¼ in
1–2 cm

STALKED PUFFBALL-IN-ASPIC
Calostoma cinnabarinum
F: Calostomataceae

From North America, this species' bright cinnabar-red ball on a stem emerges from a gelatinous layer.

2–39 in
5–100 cm

WET ROT
Coniophora puteana
F: Coniophoraceae

Found worldwide, this fungus forms a brown sheet of tissue, often warty or wrinkled, on wet wood. It causes serious damage to buildings.

2–3½ in
5–9 cm

BAROMETER EARTHSTAR
Astraeus hygrometricus
F: Diplocystidiaceae

Frequent in North America and Eurasia, its starlike arms peel back to reveal the inner spore-filled ball, but close again in dry weather.

2–3¼ in
5–8 cm

CORNFLOWER BOLETE
Gyroporus cyanescens
F: Gyroporaceae

Growing in acidic soil in eastern North America and Eurasia, this uncommon species is distinguished by its brittle, hollow stem.

1¼–2 in
3–5 cm

ROSY SPIKE
Gomphidius roseus
F: Gomphidiaceae

Growing in association with the bolete *Suillus bovinus* under pines in Eurasia, this fungus has a slimy, rose-pink cap with grayish gills.

1½–3¼ in
4–8 cm

COPPER SPIKE
Chroogomphus rutilus
F: Gomphidiaceae

Common under pines in western North America and Eurasia; this species has a pointed, coppery brown cap.

2¼–6 in
6–15 cm

BROWN ROLLRIM
Paxillus involutus
F: Paxillaceae

Common in mixed woods in North America and Eurasia; the downy, inrolled cap margin and soft yellow gills staining brown characterize this species.

1½–4 in
4–10 cm

COMMON EARTHBALL
Scleroderma citrinum
F: Sclerodermataceae

This potatolike fungus is common in damp woodland in North America and Eurasia; its thick skin has dark scales and a spore-filled black interior.

¾–2 in
2–5 cm

POTATO EARTHBALL
Scleroderma borista
F: Sclerodermataceae

Common in woods in North America and Eurasia; its smooth outer skin cracks into a fine mosaic. The inner purple-black spore-mass dries brownish.

¾–3¼ in
2–8 cm

FALSE CHANTERELLE
Hygrophoropsis aurantiaca
F: Hygrophoropsidaceae

Sometimes mistaken for a chanterelle, this species from North America and Eurasia is distinguished by its crowded, multiforked, soft gills.

4–12 in
10–30 cm

VELVET ROLLRIM
Tapinella atrotomentosa
F: Tapinellaceae

Common on pine stumps in North America and Eurasia; it has a cap with an inrolled margin; soft, thick gills; and a velvety stem.

2–4 in
5–10 cm

DYEBALL
Pisolithus arhizus
F: Sclerodermataceae

This species is found worldwide in poor, sandy soils associated with pines. The egglike spore sacs in its interior are embedded in blackish jelly.

cap skin peels off

1½–4 in
4–10 cm

dots can weep milky latex

WEEPING BOLETE
Suillus granulatus
F: Suillaceae

Common under pines in North America and Eurasia; its ringless stem is covered with glandular dots.

2–4 in
5–10 cm

SLIPPERY JACK
Suillus luteus
F: Suillaceae

Found on pines in North America and Eurasia; this fungus has a slimy cap and yellow pores. The large ring on its stem has a lavender underside.

1¼–2⅝ in
3–7 cm

BOVINE BOLETE
Suillus bovinus
F: Suillaceae

Common under pines in North America and Eurasia; this species has a sticky cap and angular, irregular pores.

2–4 in
5–10 cm

LARCH BOLETE
Suillus grevillei
F: Suillaceae

Confined to larch woods in North America and Eurasia; this species is a yellow-orange to brick-red color. The stem has an ascending ring.

yellow-brown cap surface is dry and rough

2¾–5 in
7–13 cm

VELVET BOLETE
Suillus variegatus
F: Suillaceae

Frequent under pines in Eurasia; this species has a felty-scaly cap, with dark cinnamon-brown pores, and a ringless stem.

CANTHARELLALES

The species of the Cantharellales order may look like agarics (members of the Agaricales order), but differ in several important respects. They may have fleshy fruitbodies with a cap and stem, but they lack true gills, having instead a smooth, wrinkled, or folded gill-like spore-producing surface on the underside. The spores are smooth and usually white to cream.

¼–¾ in
0.5–2 cm

HORN OF PLENTY
Craterellus cornucopioides
F: Cantharellaceae

A distinctive species found throughout Eurasia; this thin trumpet grows in troops in beech leaf litter. It produces a white spore deposit.

⅜–2¾ in
1–6 cm

TRUMPET CHANTERELLE
Craterellus tubaeformis
F: Cantharellaceae

Often found in large troops in mixed woods in North America and Eurasia; this fungus has a variable color and shallow, blunt veins rather than gills.

1¼–3¼ in
3–8 cm

CRESTED CORAL
Clavulina coralloides
F: Clavulinaceae

Very common in woods in North America and Eurasia; this fungus forms a coral-like mass of white branches, each dividing into fine points.

2–6 in
5–15 cm

cap often depressed at center

irregular, often lobed cap

WOOD HEDGEHOG
Hydnum repandum
F: Hydnaceae

Occurring in North America and Eurasia; this dusky orange species is irregular in shape, with tiny spines underneath the cap.

inrolled margin

¾–4¾ in
2–12 cm

CHANTERELLE
Cantharellus cibarius
F: Cantharellaceae

Found in North America and Eurasia; this species has blunt-edged gills with numerous cross-veins and a smell of apricots.

tapered stem

GEASTRALES

The Geastrales, or earthstars, share the common character of a thick outer layer—the peridium—which splits apart and peels back to form starlike arms. These reveal a central spore sac, like a puffball, from which the dark brown, warted spores exit via a pore at the apex. Earthstars are found in leaf litter and bare, sandy soil—for example, in sand dunes.

STRIATE EARTHSTAR
Geastrum striatum
F: Geastraceae

Found in Eurasia; this is one of the smaller earthstars. Its pale gray spore sac is stalked and has a sharply pointed, striated opening.

1¼–2½ in
3–6.5 cm

collar below spore sac

1½–4¾ in
4–12 cm

COLLARED EARTHSTAR
Geastrum triplex
F: Geastraceae

Growing in North America and Eurasia; this is the most common earthstar. Its rays crack to leave a cuplike collar around the spore sac.

1¼–2¼ in
3–6 cm

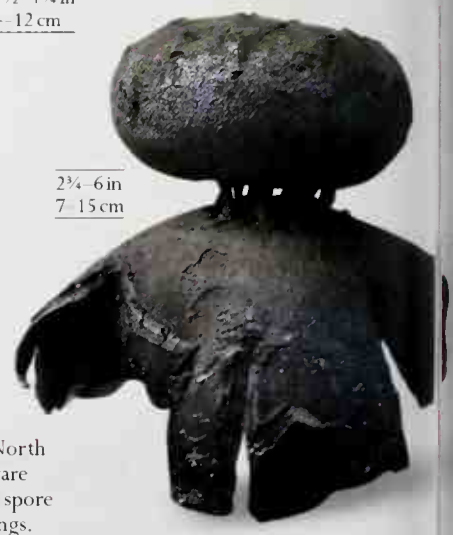
SESSILE EARTHSTAR
Geastrum fimbriatum
F: Geastraceae

Found in North America and Eurasia; this fungus's globe-shaped, pale brown fruitbody splits open with 5–9 arms. Its grayish spore sac has a fringed opening.

2–3¼ in
5–8 cm

ARCHED EARTHSTAR
Geastrum fornicatum
F: Geastraceae

This earthstar's arms stay attached to a disc of tissue in the soil, and its stalked spore sac has a prominent opening. It occurs in North America and Eurasia.



2¾–6 in
7–15 cm

PEPPER POT
Myriostoma coliforme
F: Geastraceae

Found in dry, sandy soils in North America and Eurasia; this rare species has a distinctive, large spore sac with several pore openings.

GOMPHALES

Although some species were included with the chanterelles in Cantharellales, DNA analysis of the Gomphales fungi suggests that they are more closely related to the stinkhorn fungi in the Phallales. They often form large fruitbodies, varying in shape from simple clubs (in genus *Clavariadelphus*) to trumpet- or chanterelle-like structures with a complex spore-producing surface (in genus *Gomphus*).

¾–2¼ in
2–6 cm

GIANT CLUB
Clavariadelphus pistillaris
F: Clavariadelphaceae

A rare species of North America and Eurasia; this fungus forms a large, swollen club, with a smooth to slightly wrinkled surface, which bruises purple-brown.

2–4 in
5–10 cm

SCALY VASE CHANTERELLE
Gomphus floccosus
F: Gomphaceae

Common in North America, this resembles a fleshy, trumpet-shaped vase with scales at the top and wrinkled "gills" on its undersurface.

1¼–3 in
3–8 cm

GREENING CORAL
Ramaria abietina
F: Gomphaceae

Found in conifer woods in North America and Eurasia; this yellow-olive fungus has densely packed branches that bruise green.

1¼–3 in
3–8 cm

UPRIGHT CORAL
Ramaria stricta
F: Gomphaceae

A fairly common species in North America and Eurasia; it is always attached to decaying wood or wood-chip mulch. The branches are pale brown, bruising reddish.

2½–6 in
7–15 cm

ROSSO CORAL
Ramaria botrytis
F: Gomphaceae

Found in beech woods in North America and Eurasia; this uncommon coral fungus has pinkish white branches with deep red tips.

GLOEOPHYLLALES

This is an order of wood-decay fungi that is characterized by the ability to produce a brown rot of wood. The order Gloeophyllales has a single family, the Gloeophyllaceae, which includes the genus *Gloeophyllum*. Some well-known bracket fungi on conifer wood are members of this genus.

2–8 in
5–20 cm

ANISE MAZEGILL
Gloeophyllum odoratum
F: Gloeophyllaceae

This fungus, which grows on decayed conifer wood, is found in North America and Eurasia; it has irregular brackets with yellow pores and an aniseed odor.

DACRYMYCETALES

This order forms very simple, rounded or branched gelatinous fruitbodies, usually with bright orange coloration. Smooth or wrinkled, the Dacrymycetales have unusual spore-producing cells (basidia), which typically have two stout stalks (sterigmata), each bearing a spore. They mainly feed on dead wood.

YELLOW STAGSHORN
Calocera viscosa
F: Dacrymycetaceae

Attached to conifer wood, this is found in North America and Eurasia; its clubs usually divide into branches with a gelatinous, rubbery texture.

HYMENOCHAETALES

This group contains a number of diverse types of fungi including some crust fungi, polypores, such as *Inonotus* and *Phellinus*, as well as several agaric species, such as *Rickenella*. The Hymenochaetales are defined through molecular studies and have few uniting physical characteristics. Many feed on wood and may cause a white rot of wood.

¾–2¼ in
1–6 cm

OAK CURTAIN CRUST
Hymenochaete rubiginosa
F: Hymenochaetaceae

Found across Eurasia; this fungus forms overlapping brackets and crusts mainly on fallen oak. Its tough fruitbodies have concentric markings.

4–16 in
10–40 cm

WILLOW BRACKET
Phellinus igniarius
F: Hymenochaetaceae

This gray to almost black perennial bracket from North America and Eurasia grows over many years. It is hoof-shaped and extremely woody.

1¼–3½ in
3–8 cm

ALDER BRACKET
Inonotus radiatus
F: Hymenochaetaceae

This deep reddish brown fungus with a paler margin often forms vertical chains of brackets on alder and other trees in North America and Eurasia.

¾–4 in
2–10 cm

TIGER'S EYE
Coltricia perennis
F: Hymenochaetaceae

Frequently found in acidic meadows of North America and Eurasia; this fungus's goblet-shaped, thin fruitbodies are concentrically zoned.

⅛–¾ in
0.3–1 cm

ORANGE MOSSCAP
Rickenella fibula
F: Incertae sedis in Rickenella clade

This tiny species is common in mossy grasslands of North America and Eurasia; its bright orange cap is radially marked with a darker center.

POLYPORALES

The Polyporales form a large group of diverse fungi. Most of these are polypores—wood decomposers whose spores are formed in tubes (somewhat like the tubes of the boletes) or sometimes on spines. Most lack fully developed stems and grow shelf-, bracket-, or crust-like fruitbodies on wood, but some have more or less central stems and grow at the base of trees. A few Polyporales appear to grow from soil.

OAK MAZEGILL
Daedalea quercina
F: Fomitopsidaceae
Found on fallen oaks in North America and Eurasia; this perennial species has tough brackets with long mazelike pores on the underside.

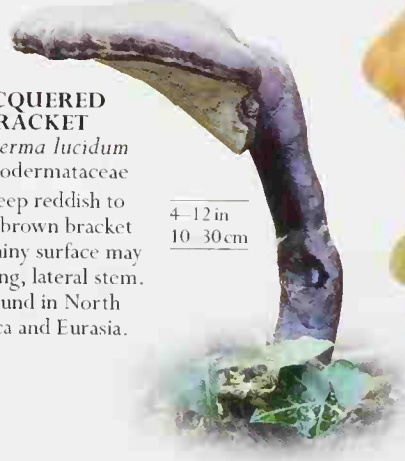
DYER'S MAZEGILL
Phaeolus schweinitzii
F: Fomitopsidaceae
Usually found at the base of conifers in North America and Eurasia; this large, furry, cushionlike bracket is used for the manufacture of dye.
4–20 in
10–50 cm

RED BELTED POLYPORE
Fomitopsis pinicola
F: Fomitopsidaceae
Occurring in North America and Eurasia; this hoof-shaped, woody bracket is usually found on pines, and sometimes on birches.

RAZORSTROP FUNGUS
Piptoporus betulinus
F: Fomitopsidaceae
This large, kidney-shaped bracket is pale brown to white. A damaging parasite of birches, it is found in North America and Eurasia.

CHICKEN OF THE WOODS
Laetiporus sulphureus
F: Fomitopsidaceae
These large brackets, found in North America and Eurasia; usually grow on oaks and sometimes on other trees.

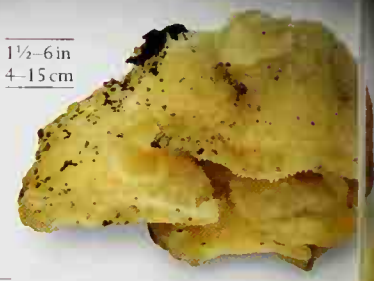
ARTIST'S BRACKET
Ganoderma applanatum
F: Ganodermataceae
Found in North America and Eurasia; this woody perennial bracket grows for many years to reach huge sizes. Its fallen spores are a rich cinnamon-brown.



LACQUERED BRACKET
Ganoderma lucidum
F: Ganodermataceae
This deep reddish to purple-brown bracket with a shiny surface may have a long, lateral stem. It is found in North America and Eurasia.

GIANT POLYPORE
Meripilus giganteus
F: Meripilaceae
One of the largest polypores, its overlapping brackets are thick and fleshy. It grows around beech and other trees in North America and Eurasia.

ZONED ROSETTE
Podoscypha multizonata
F: Meruliaceae
Growing in soil from buried oak roots, this rare species occurs in Eurasia; it has densely packed lobes that form a circular mass.



JELLY ROT
Phlebia tremellosa
F: Meruliaceae
Found on logs in Eurasia; this species has a pale, velvety upper side and a yellow-to-orange underside with dense ridges.

SMOKY BRACKET
Bjerkandera adusta
F: Meruliaceae
This common bracket, found in North America and Eurasia; can be identified by the ash-gray pore surface on its underside.

2–12 in
5–30 cm

TINDER BRACKET
Fomes fomentarius
F: Polyporaceae

This gray-brown, hoof-shaped, perennial bracket grows on birches and other deciduous trees. It is found in North America and Eurasia.

3¼–6 in
8–15 cm

BLUSHING BRACKET
Daedaleopsis confragosa
F: Polyporaceae

One of the most common brackets, especially on willows, in N. America and Eurasia; this semicircular species has cream pores that bruise pinkish red.

1¼–4 in
3–10 cm

BIRCH MAZEGILL
Lenzites betulina
F: Polyporaceae

Usually found on birches in North America and Eurasia; this tough, leathery species has pores that can be extremely elongated in gill-like ridges.

4–23½ in
10–60 cm

DRYAD'S SADDLE
Polyporus squamosus
F: Polyporaceae

Found in early summer in North America and Eurasia, these circular or fan-shaped brackets have concentric scales and pores on the underside.

2–8 in
5–20 cm

BLACK FOOTED POLYPORE
Polyporus badius
F: Polyporaceae

This fungus has a funnel-shaped, leathery cap and its stem is black at the base. It grows on fallen beech logs in North America and Eurasia.

2–8 in
5–20 cm

TUBEROUS POLYPORE
Polyporus tuberaster
F: Polyporaceae

Growing on fallen branches in North America and Eurasia; this species may root into the ground and form a large, tuberous mass.

1¼–3½ in
3–8 cm

WINTER POLYPORE
Polyporus brumalis
F: Polyporaceae

This small species grows on fallen branches in North America and Eurasia; it has somewhat large, decurrent (running down the stem) pores. The stem is central or off-center.

1¼–4 in
3–10 cm

CINNABAR BRACKET
Pycnoporus cinnabarinus
F: Polyporaceae

Growing on dead deciduous wood in North and America and Eurasia; this rare species has a bright reddish orange, leathery, annual bracket.

¾–1½ in
2–4 cm

PURPLEPORE BRACKET
Trichaptum abietinum
F: Polyporaceae

Found on fallen conifers in North America and Eurasia; this fan-shaped bracket has concentric zones of pale gray, often tinged green by algae, with a purple margin.

2–4¾ in
5–12 cm

HAIRY BRACKET
Trametes hirsuta
F: Polyporaceae

This semicircular bracket is covered in minute hairs. It grows on dead deciduous wood or sometimes on old gorse stems in North America and Eurasia.

¾–2¾ in
2–7 cm

TURKEYTAIL
Trametes versicolor
F: Polyporaceae

Found in North America and Eurasia in a variety of colors, this species has brackets with concentric zones of different colors and a white pore surface.

¾–2¾ in
2–6 cm

HEN OF THE WOODS
Grifola frondosa
F: Sparassidaceae

Found in North America and Eurasia; this species grows at the base of oak, often where lightening has struck. It has a dense cluster of small brackets.

4–12 in
10–30 cm

4–16 in
10–40 cm

WOOD CAULIFLOWER
Sparassis crispa
F: Sparassidaceae

Growing at the base of conifers in North America and Eurasia, this species has cream lobes that are flattened and fleshy like a cauliflower.

LUMPY BRACKET
Trametes gibbosa
F: Polyporaceae

This cream-colored bracket is often stained green from algae. Its pores may be long and mazelike. It grows on fallen deciduous logs in North America and Eurasia.

RUSSULALES

The best-known genuses within this order are *Russula* and *Lactarius*, which, although resembling typical mushrooms, are not related at all to the true Agaricales. Apart from the cap-and-stem shapes, Russulales produce fruitbodies in a wide range of forms. Most Russulales have spores with warts that stain blue-black in iodine solutions. When cut, the *Lactarius* species produce a latex, which may be white to colored.

1¾–2¾ in
3–6 cm

LIVER MILKCAP
Lactarius hepaticus
F: Russulaceae

Associated with pines in Eurasia; this mushroom has a smooth cap with a grooved margin. The gills bleed a white latex that stains yellow when cut.

1½–3¼ in
4–8 cm

OAKBUG MILKCAP
Lactarius quietus
F: Russulaceae

Common under oaks in Eurasia; its reddish brown cap has darker zones, and the flesh has a sweet, oily smell.

2–6 in
5–15 cm

UGLY MILKCAP
Lactarius turpis
F: Russulaceae

A common species of birch woods in North America and Eurasia; it is olive-green to almost black in color and has a slimy cap.

1½–3½ in
4–9 cm

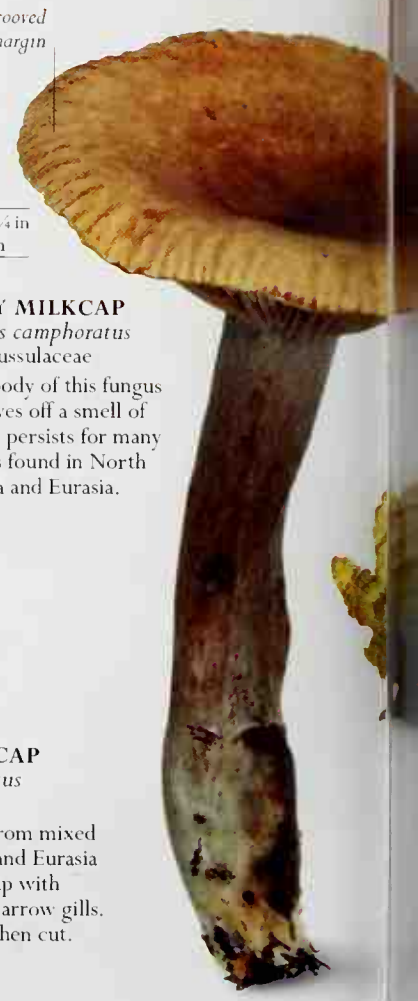
BEECH MILKCAP
Lactarius blennius
F: Russulaceae

This is a common species growing with beech in Eurasia. Slimy when wet, the gray-green cap has spots around the margin.

2–6 in
5–15 cm

SAFFRON MILKCAP
Lactarius deliciosus
F: Russulaceae

Found with pines in North America and Eurasia; this fungus has an orange-zoned and spotted cap that stains green with age. The flesh bleeds orange-red latex.



2–6 in
5–15 cm

WOOLLY MILKCAP
Lactarius torminosus
F: Russulaceae

Common under birches in North America and Eurasia; this mushroom has a dark pink, hairy cap that is strikingly zoned.

1¾–2¾ in
3–6 cm

CURRY MILKCAP
Lactarius camphoratus
F: Russulaceae

As the fruitbody of this fungus dries, it gives off a smell of curry, which persists for many weeks. It is found in North America and Eurasia.

2¾–4 in
6–10 cm

SOOTY MILKCAP
Lactarius fuliginosus
F: Russulaceae

Found in deciduous woods in Eurasia; this uncommon species has a dark brown cap and stem that bleed a white latex that rapidly turns pink.

3¼–8 in
8–20 cm

PEPPERY MILKCAP
Lactarius piperatus
F: Russulaceae

This uncommon species from mixed woods in North America and Eurasia has a funnel-shaped cap with extraordinarily crowded, narrow gills. It exudes white latex when cut.

dry, smooth cap surface

2–6 in
5–15 cm

CHARCOAL BURNER
Russula cyanoxantha
F: Russulaceae

Growing in mixed woods in North America and Eurasia; this mushroom's cap varies from purple-lilac to uniformly green. The gills are forked, flexible, and oily.

2–4 in
5–10 cm

BLOODY BRITTLEGILL
Russula sanguinaria
F: Russulaceae

Associated with pines in North America and Eurasia; this species has a scarlet cap and red-streaked stem. Its spores are pale ocher.

1½–3½ in
4–9 cm

GREEN BRITTLEGILL
Russula aeruginea
F: Russulaceae

Common under birches in North America and Eurasia; this mushroom's pale olive to grass-green cap has tiny rust-colored spots. Its spores are pale cream.

1½–2¾ in
3–7 cm

BEECHWOOD SICKENER
Russula nobilis
F: Russulaceae

Exclusively found with beech in Eurasia, this species has a scarlet cap and bluish white gills.

2–4 in
5–10 cm

YELLOW SWAMP BRITTLEGILL
Russula claroflava
F: Russulaceae

A common species on moss in boggy birch woods in North America and Eurasia; its cap, yellowish cream gills, and white stem all bruise gray-black.

2–4¾ in
5–12 cm

OCHER BRITTLEGILL
Russula ochroleuca
F: Russulaceae

One of the most common species found in Eurasia, it is identifiable by its matte yellow-ocher or greenish yellow cap and white gills.

1½–3¼ in
3–8 cm

SICKENER
Russula emetica
F: Russulaceae

Growing in wet pine woods in North America adn Eurasia; the sickener has a bright scarlet cap that contrasts with its pure white gills and stem.

dry and matte cap surface

1½–4¾ in
4–12 cm

gills may have red edges

1½–4 in
4–10 cm

PRIMROSE BRITTLEGILL
Russula sardonia
F: Russulaceae

Found in Eurasia, this species grows in association with pine. Variable in color, from purple to green or yellow, it has a fruity odor.

3¼–6 in
8–15 cm

STINKING BRITTLEGILL
Russula foetens
F: Russulaceae

This large, orange-brown fungus with a grooved, lumpy cap margin grows in North America and Eurasia. It has a sour, rancid odor.

stem often flushes red

ROSY BRITTLEGILL
Russula rosea
F: Russulaceae

Found in Eurasia; this fungus has a carmine-red, dry, hard cap that fades rapidly. Its stem may also be red and the flesh has a smell similar to cedar.

2¾–6 in
6–15 cm

CRAB BRITTLEGILL
Russula xerampelina
F: Russulaceae

Found in North America and Eurasia; this fungus is one of many related species that can only be identified under a microscope or by habitat.

EARPICK FUNGUS
Auriscalpium vulgare
F: Auriscalpiaceae

Growing on pinecones in North America and Eurasia; this unique mushroom looks like a bent-over spoon with minute spines hanging down from the small, furry cap.

3/16–¾ in
0.5–2 cm

¾–2¾ in
2–6 cm

4–20 in
10–50 cm

HAIRY CURTAIN CRUST
Stereum hirsutum
F: Stereaceae

Found in North America and Eurasia; this mushroom varies in shape from fully crustlike to small overlapping brackets. It is hairy above and smooth below.

BLEEDING BROADLEAF CRUST
Stereum rugosum
F: Stereaceae

Growing in North America and Eurasia; this species forms small crusts, and occasionally small brackets on wood. Its upper surface bleeds red when cut.

2–10 in
5–25 cm

ROOT ROT
Heterobasidion annosum
F: Bondarzewiaceae

Usually parasitic on conifers in North America and Eurasia; this species has a pale brown crust that darkens with age.

4–16 in
10–40 cm

CORAL TOOTH
Hericium coralloides
F: Hericiaceae

Usually found on beech trees in North America and Eurasia; this endangered species has white fruitbody branches with pendent spines on the lower surfaces.

AURICULARIALES

Although often grouped with other jelly fungi, the Auriculariales are separated by their unusual basidia (spore-producing cells). These vary in shape but all are partitioned by dividing membranes into four divisions, with each division producing a spore.

TRIPE FUNGUS
Auricularia mesenterica
F: Auriculariaceae
1½–6 in
4–15 cm

Found in Eurasia; this species is common on dead wood, especially elm. It resembles a small bracket fungus from the top, and has a wrinkled, rubbery, grayish purple underside.

¾–4 in
2–10 cm

WITCHES' BUTTER
Exidia glandulosa
F: Auriculariaceae

Found in temperate North America and Eurasia, frequently on hardwood trees; it resembles a wrinkled mass of gelatinous tar. It shrivels when dry to a hard, black mass.

1½–4¾ in
4–12 cm

JELLY EAR
Auricularia auricula-judae
F: Auriculariaceae

Common on dead wood of deciduous trees in North America and Eurasia; this fungus has thin, elastic "ears" that are velvety outside and wrinkled inside.

JELLY TOOTH
Pseudohydnum gelatinosum
F: Incertae sedis

This species from North America and Eurasia has a pale translucent gray to pale brown coloration. It is occasionally found on conifer stumps.

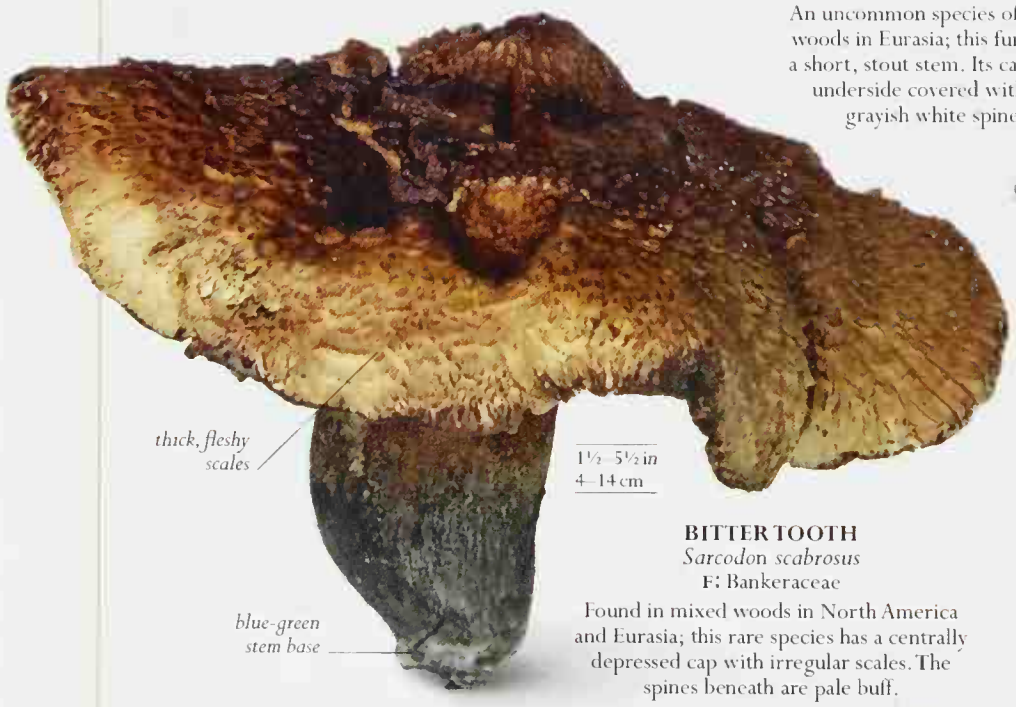
THELEPHORALES

This diverse group includes bracket fungi, crust fungi, earthfans, and toothed fungi. Many of these have tough, leathery flesh, and commonly feature knobbed or spiny spores. The group was only identified as a result of molecular studies since the Thelephorales have few physical features in common.

2–4 in
5–10 cm

DRAB TOOTH
Bankera fuligineoalba
F: Bankeraceae

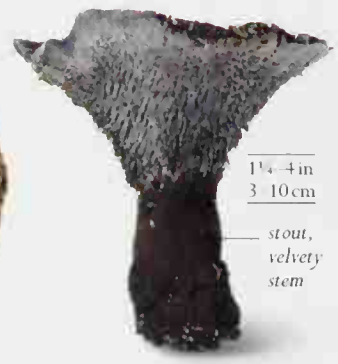
An uncommon species of conifer woods in Eurasia; this fungus has a short, stout stem. Its cap has an underside covered with tiny grayish white spines.



1½–5½ in
4–14 cm

BITTER TOOTH
Sarcodon scabrosus
F: Bankeraceae

Found in mixed woods in North America and Eurasia; this rare species has a centrally depressed cap with irregular scales. The spines beneath are pale buff.



1¼–4 in
3–10 cm

BLACK TOOTH
Phellodon niger
F: Bankeraceae

Growing in mixed woods in North America and Eurasia; this uncommon species smells of fenugreek when dry. The irregularly shaped cap is gray to purplish black with gray spines underneath.

1¼–6 in
3–15 cm

DEVIL'S TOOTH
Hydnellum peckii
F: Bankeraceae

This locally common species from conifer woods in North America and Eurasia has a flattened, knobby, woolly cap that often exudes blood-red droplets. The underside has pale brown spines.

1½–4 in
4–10 cm

EARTHFAN
Thelephora terrestris
F: Thelephoraceae

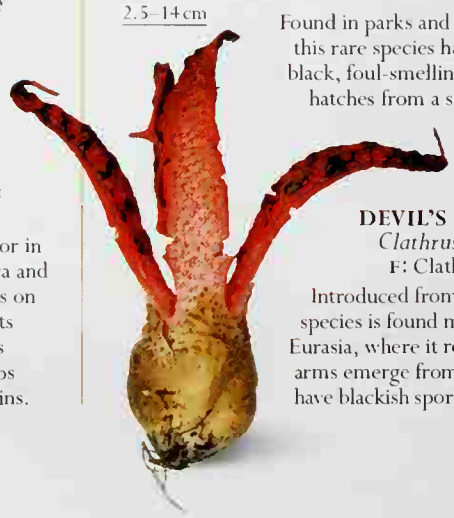
Quite common in woods or in meadows in North America and Eurasia; this fungus grows on soil or woody debris. Its fan-shaped fruitbodies overlap, forming clumps with paler, fringed margins.

PHALLALES

Named for the phallic shape of many of the species in this group, such as the stinkhorns, this order also contains some false truffles. The stinkhorns "hatch" from an egglike structure, often in just a few hours.

RED CAGE FUNGUS
Clathrus ruber
F: Clathraceae

Found in parks and gardens in Eurasia; this rare species has a red cage with black, foul-smelling spores. The cage hatches from a small, pale "egg."



1–5½ in
2.5–14 cm

DEVIL'S FINGERS
Clathrus archeri
F: Clathraceae

Introduced from Australasia, this species is found mainly in southern Eurasia, where it remains rare; its red arms emerge from a white "egg" and have blackish spores that smell fetid.

EXOBASIDIALES

This small group consists mainly of gall-forming plant parasites whose spore-producing cells form a layer on the leaf surface. Some cause disease in cultivated plants of the *Vaccinium* genus, which includes the common blueberry.

EXOBASIDIUM VACCINII
F: Exobasidiaceae

Found in North America and Eurasia, this common fungus infects cowberry and eventually turns the leaves bright red. The leaves may become distorted and gall-like.

UROCYSTIDIALES

This order contains some well-known smut fungi, in particular species of the genus *Urocystis*. These are parasites of flowering plants such as anemone, onions, wheat, and rye, and often cause serious injury to the host plant.

ANEMONE SMUT
Urocystis anemones
F: Urocystidaceae

This smut fungus from North America and Eurasia forms dark brown, powdery, raised pustules on the leaves of anemones and some other plants.

DOG STINKHORN
Mutinus caninus
F: Phallaceae

This common stinkhorn is found in mixed woods in North America and Eurasia; its tip, covered in greenish black spores, is joined to the spongy stem that emerges from a white "egg."

¾–4¾ in
1–12 cm

2–8 in
5–20 cm

PHALLUS MERULINUS
F: Phallaceae

This tropical species is mainly found in Australasia, it hatches from a white "egg." There are many similar species, some with brightly colored "skirts."

2–8 in
5–20 cm

STINKHORN
Phallus impudicus
F: Phallaceae

Common in mixed woods, this fungus is found in Eurasia; its spore-covered, honeycomb-like cap hatches in a few hours from an "egg." Its foul odor is often evident many yards away.

PUCCINIALES

One of the largest orders of fungi with over 7,000 species, the rust fungi include numerous serious parasites of crop plants. They can have very complex life cycles with multiple hosts and produce different types of spores at different stages in their life.

RASPBERRY YELLOW RUST
Phragmidium rubi-idaei
F: Phragmidiaceae

This rust from North America and Eurasia causes pustules to form on the upper surface of leaves. It survives winter with the help of black spores on the underside of leaves.

ROSE RUST
Phragmidium tuberculatum
F: Phragmidiaceae

This common rust is found in North America and Eurasia; it causes orange pustules on the undersides of leaves and on distorted stems. The pustules turn black in late summer.

ALEXANDERS RUST
Puccinia smyrnii
F: Pucciniaceae

Found across Eurasia; this common rust fungus forms raised plaques or warts on the leaves of Alexanders (*Smyrnium olusatrum*).

HOLLYHOCK RUST
Puccinia malvacearum
F: Pucciniaceae

This serious pest of hollyhocks is found in North America and Eurasia; it covers the leaves with small pustules. Older leaves die and fall off.

PUCCINIA ALLII
F: Pucciniaceae

Common on onions, garlic, and leeks in North America and Eurasia; this species forms pustules on infected leaves. These break open to release dustlike airborne spores.

HYPERICUM RUST
Melampsora hypericorum
F: Melampsoraceae

This common species from Eurasia is visible as scattered, raised pustules on the undersides of *Hypericum* leaves.

FUCHSIA RUST
Pucciniastrum epilobii
F: Pucciniastraceae

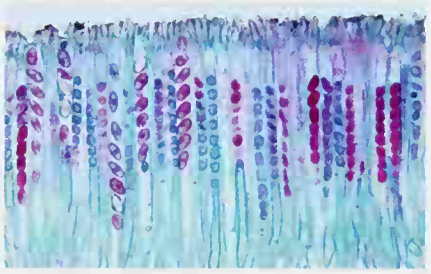
A parasite of fuchsias and fireweed in Eurasia; this species infects the leaves and forms pustules on the undersides of the leaves.

SAC FUNGI

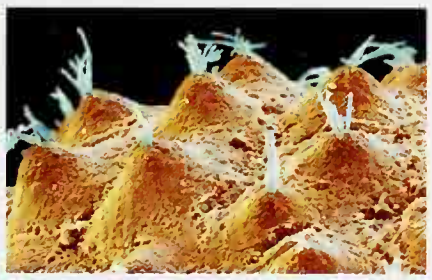
The Ascomycota, or sac fungi, are fungi that produce their spores in little sacs called asci located on the fruitbody—the part of the fungus that projects above ground. They are the largest group of fungi, and include many cup- and saucer-shaped species.

PHYLUM	ASCOMYCOTA
CLASSES	7
ORDERS	56
FAMILIES	226
SPECIES	About 33,000

Many sac fungi display vivid colors, although it is uncertain what biological function such bright colors may have.



Spore-producing asci are shown here under a microscope. Arranged in dense layers, the asci contain eight spores each.



Many species form their asci in special protective chambers called perithecia; from here they discharge their spores.

DEBATE

HEROES OR VILLAINS?

Sac fungi form beneficial associations with plants, algae, and even arthropods such as beetles. But equally they include some of the world's most damaging pathogens: *Cryphonectria*, for example, is responsible for the recent death of millions of chestnut trees. Perhaps no other group of fungus has such contrasting effects on our world.

Ranging in size from the microscopic to around 8 in (20 cm) in height, the sac fungi occupy a wide variety of habitats, growing on dead, dying, and living tissue, and floating in fresh and saltwater environments. Many species are parasitic, and include some of the most serious crop pests. Others form mutually beneficial relationships, called mycorrhizae, with plants. Sac fungi include some of the most important fungi in the history of medicine, such as the source of penicillin, while others are serious pathogens—*Pneumocystis jirovecii*, for instance, can cause lung infections in people with a weak immune system. This phylum also contains the yeasts, which, being vital components in the production of alcohol and bread, have played a pivotal role in human history.

The Ascomycota display a wide range of fruitbody shapes, including cup-shaped, club-shaped, potato-like, simple crusts or sheets, pimplelike, coral-like, shield-shaped, or stalked with a spongelike cap. Depending on the type of fruitbody, the spore-producing asci may grow externally on a special fertile layer or be contained internally. Not all species have a sexual stage; in fact, many use asexual methods of reproduction. Most yeasts grow and rapidly colonize new areas as a result of asexual division, or budding, where a small bud forms on the outside of a yeast cell, then separates, becoming a new cell.

THE CUP FUNGUS

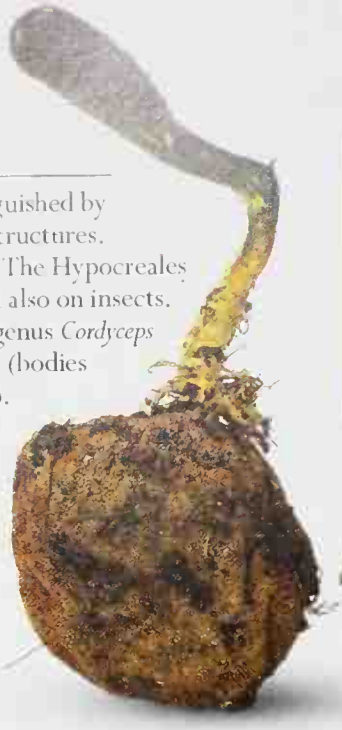
The common name of cup fungus refers to one of the most conspicuous shapes of fruitbody associated with the Ascomycota. Its open top (which is sometimes disk- or saucer-shaped) allows wind and rain to scatter the spores that line its inner surface. In some varieties, water is absorbed by the asci, which contain the spores, so that pressure builds up and forcibly ejects the spores up to 12 in (30 cm) from the fruitbody. Close examination of surfaces such as rotting logs, fallen branches, or leaves may reveal a fascinating world of almost microscopic cups. In the larger cup species, disturbance of the cup can produce such a vigorous ejection of spores that their release is not only visible as a faint cloud of spores, but also audible.

ORANGE PEEL CUP >
The orange peel fungus is a good example of the simple cup-shaped fruitbody adopted by many fungi species.

HYPOCREALES

The fungi in this order are usually distinguished by their brightly colored, spore-producing structures. These are usually yellow, orange, or red. The Hypocreales are often parasitic on other fungi and also on insects. The best known among them is the genus *Cordyceps* with club- or branch-like fruitbodies (bodies that support the spore-forming cells). Some species have medicinal uses.

SCARLET CATERPILLAR CLUB
Cordyceps militaris
F: Cordycipitaceae
Found in North America and Eurasia; this fungus is parasitic on moth pupae. The head of its club bears tiny spore-producing structures.



SNAKETONGUE TRUFFLECLUB
Elaphocordyceps ophioglossoides
F: Ophiocordycipitaceae
Parasitic on buried false truffles, this species is found in North America and Eurasia; it forms yellowclubs with an elongated, greenish black head.

CORAL SPOT
Nectria cinnabarina
F: Nectriaceae
Abundant on damp wood in North America and Eurasia; this fungus forms pink "pimples" when sexually immature and red-brown clusters when mature.

ERGOT
Claviceps purpurea
F: Clavicipitaceae
This species has caused outbreaks of mass poisoning. Found in North America and Eurasia, it is parasitic on grass and cereal crops.

BOLETE EATER
Hypomyces chrysospermus
F: Hypocreaceae
This common mold, found in N. America and Eurasia on bolete, turns bright golden yellow, with a fluffy texture.

XYLARIALES

Members of this order often have their spore-producing cells in chambers, which are embedded in a woody growth called stroma. Although many species live on wood, some also occur on animal dung, fruit, leaves, and soil, or are associated with insects. The order includes many economically important plant parasites.

NAIL FUNGUS
Poronia punctata
F: Xylariaceae
Found in horse dung in North America and Eurasia; this species is in decline. Its flattened disc has numerous tiny holes from which spores are released.

CANDLESTUFF FUNGUS
Xylaria hypoxylon
F: Xylariaceae
Common on dead wood in North America and Eurasia; this species resembles a snuffed-out candle with a velvety black stem.

DEAD MAN'S FINGERS
Xylaria polymorpha
F: Xylariaceae
Growing on dead wood in North America and Eurasia; this fungus forms brittle black clubs with a rough surface, tiny pores, and thick, white flesh.

BEECH WOODWART
Hypoxylon fragiforme
F: Xylariaceae
Occurring in clusters on beech logs in North America and Europe; it forms hard, rounded fruitbodies with tiny spore-releasing chambers.

CRAMP BALLS
Daldinia concentrica
F: Xylariaceae
Found in North America and Eurasia; this fungus has rounded fruitbodies that reveal concentric whitish zones when cut in half. They eject black spores from their outer layer.

ERYSIPHALES

Parasitic on leaves and fruit of flowering plants, the Erysiphales are powdery mildews. The hyphae (filaments) of their mycelium (vegetative part of the fungus) penetrate the cells of the host plant and take up nutrients.

OAK POWDERY MILDEW
Erysiphe alphitoides
F: Erysiphaceae
Growing on oaks in North America and Eurasia; this fungus covers young leaves, causing them to shrivel and blacken.

APPLE POWDERY MILDEW
Podosphaera leucotricha
F: Erysiphaceae
Common on apple leaves in North America and Eurasia; this mildew appears first on the underside of leaves as whitish patches, before spreading rapidly.

POWDERY MILDEW
Golovinomyces cichoracearum
F: Erysiphaceae
Found in North America and Eurasia; this species appears on members of Asteraceae (the sunflower family), causing patches on leaves, which eventually die.

CAPNODIALES

Commonly called sooty molds, these sac fungi are frequently found on leaves. They feed on the honeydew excreted by insects or on liquid exuded from the leaves. Some cause skin problems in humans.

CLADOSPORIUM CLADOSPORIOIDES
F: Davidiellaceae
This mold, common in North America and Eurasia, grows on damp bathroom walls. It may cause an allergic reaction in some people.

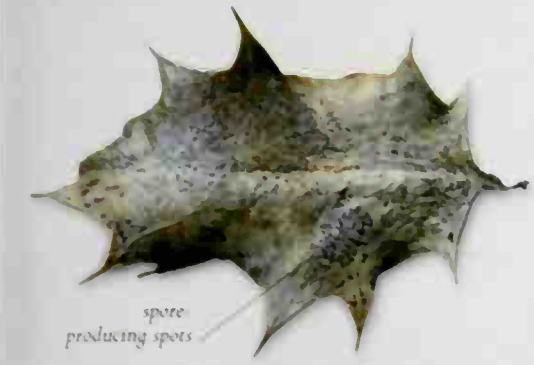
HELOTIALES

The fungi of this order are distinguished by their disc- or cup-shaped fruitbodies, unlike some similar cup fungi. Their saclike spore-producing cells, or asci, do not have an apical lid (a flap through which they open). Most members live on nutrient-rich soil, dead logs, and other organic matter. This order also includes some of the most damaging plant parasites.

1/16–3/4 in
0.5–1.5 cm

BROWN CUP
Rutstroemia firma
F: Rutstroemiaceae

Consisting of a light brown cup and a narrow stem, this fungus grows on fallen branches, especially of oaks, in Europe. It turns the host wood black.



TROCHILA ILICINA
F: Dermateaceae

Abundant on fallen holly leaves, this fungus is found in North America and Eurasia. It forms spore-producing spots on the leaf surface.

ROSE BLACK SPOT
Diplocarpon rosae
F: Dermateaceae

Commonly found on rose leaves in North America and Eurasia, this fungus causes black spots, which merge together to cause large black patches.

1/16–2 3/4 in
3–7 cm

SCALY EARTHTONGUE
Geoglossum fallax
F: Geoglossaceae

Growing in meadows in North America and Eurasia; this uncommon fungus is one of several species with blackish, flattened clubs, which can only be separated using a microscope.

1/16–3/4 in
0.2–1 cm

1/16–1 1/2 in
0.5–4 cm

BLACK BULGAR
Bulgaria inquinans
F: Bulgariaceae

Found in North America and Eurasia; this species has a brown outer surface. Its spore-producing inner surface is smooth, black, and rubbery.

1/16–1 1/4 in
0.5–3 cm

ANEMONE CUP
Dumontinia tuberosa
F: Sclerotiniaceae

Parasitic on the tubers of anemones, this common Eurasian species has a long, black stem and a simple brown cup.

1/16–1 1/4 in
0.5–3 cm

BEECH JELLYDISC
Neobulgaria pura
F: Helotiaceae

Frequently found on fallen beech logs in Eurasia; this translucent jellydisc varies from pale pink to pale lilac. The discs are often distorted from crowding together.

APPLE BROWN ROT
Monilia fructigena
F: Sclerotiniaceae

Very common in Eurasia; this fungus occurs primarily on apples and pears, although it is also found on *Prunus* sp., causing brown fruit rot.

1/32–1/8 in
1–3 mm

LEMON DISC
Bisporella citrina
F: Helotiaceae

Very common on dead hardwood in Eurasia; this species occurs in clusters. Its golden-yellow discs sometimes cover entire branches.

1/8–3/4 in
0.3–1 cm

JELLY BABIES
Leotia lubrica
F: Leotiaceae

Frequently found in mixed woodland in North America and Eurasia, this species has a lobed head with a margin that rolls back on itself.

1/16–3/4 in
0.2–1 cm

GREEN ELFCUP
Chlorociboria aeruginascens
F: Helotiaceae

Found in North America and Eurasia, the blue-green mature cups are somewhat uncommon, but the green stains they cause on fallen oak logs are easily visible.

1/16–3/4 in
0.5–2 cm

LARGE PURPLE DROP
Ascocoryne cylichnium
F: Helotiaceae

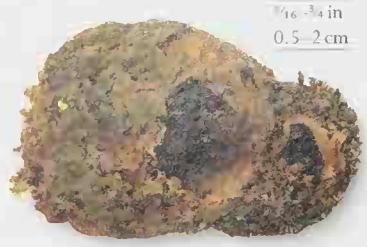
Quite common on fallen beech logs in Eurasia, this species attaches itself centrally to the wood and forms gelatinous, irregular discs when sexually mature.

BOG BEACON
Mitrula paludosa
F: Helotiaceae

This species, found in North America and Eurasia, grows on plant remains in shallow water in spring and early summer. It has a rounded to tongue-shaped head.

PEZIZALES

Members of this order produce spores inside saclike structures, or asci, which typically open by rupturing to form an operculum (terminal lid) and eject the spores. The order includes a number of species of economic importance, such as morels, truffles, and desert truffles.



3/16–3/4 in
0.5–2 cm

COMMON EARTHCUP
Geopora arenicola
F: Pyronemataceae
Common in Eurasia; this fungus is difficult to spot since it lies buried in sandy soil. It has a smooth, spore-producing inner surface.

tall orange cups

2–4 in
5–10 cm

HARE'S EAR
Otidea onotica
F: Pyronemataceae
This common species is often found in clusters in broadleaf forests in North America and Eurasia; its tall cups are split down on one side.

3/16–3/8 in
0.5–1 cm

COMMON EYELASH
Scutellinia scutellata
F: Pyronemataceae
This is one of many similar species; its fruitbody is a scarlet cup with a fringe of black hairs. This fungus is common on wet, rotten wood in North America and Eurasia.

3/16–1/2 in
0.5–1.5 cm

TOOTHED CUP
Tarzetta cupularis
F: Pyronemataceae
A common species in alkaline soil in woods of North America and Eurasia; its gobletlike cup has a short stem.

dark brown, wrinkled cap

2–6 in
5–15 cm

FALSE MOREL
Gyromitra esculenta
F: Discinaceae
This poisonous species is found throughout North America and Eurasia; it usually grows under conifers in spring. The shiny brown cap looks like a wrinkled brain.

irregular ridges and pits

ORANGE PEEL FUNGUS
Aleuria aurantia
F: Pyronemataceae
Often found along gravely dirt tracks in North America and Eurasia; this is an unmistakable species, with thin, orange caps.

3/4–4 in
2–10 cm

1 1/2–4 in
4–10 cm

BLEACH CUP
Disciotis venosa
F: Morchellaceae
Growing in spring in damp woodland in North Americ and Eurasia; this short-stemmed species has a chlorinelike smell. Its inner surface is brown and wrinkled and the outer surface is pale.

HALF-FREE MOREL
Morchella semilibera
F: Morchellaceae
This hollow morel looks like a dark, ridged thimble on a scaly, pale stem. It is common in spring in mixed woods in North America and Eurasia.

smooth cap surface

2–4 in
5–10 cm

2–6 in
5–15 cm

THIMBLE MOREL
Verpa conica
F: Morchellaceae
An uncommon species, this fungus grows in woods and hedges in chalky soils in North America and Eurasia; its smooth, thimblelike cap sits on a hollow stem.

2–6 in
5–15 cm

BLACK MOREL
Morchella elata
F: Morchellaceae
Common in woods during spring in North America and Eurasia; this species has a pinkish buff to black cap, with cross-connected black ridges, and a hollow stem.

2–8 in
5–20 cm

hollow stem

MOREL
Morchella esculenta
F: Morchellaceae
This prized species grows in spring in calcareous woodland in North America and Eurasia; it has a spongelike, hollow cap and a hollow stem.

1 1/4–4 in
3–10 cm

BLISTERED CUP
Peziza vesiculosa
F: Pezizaceae
Common in North America and Eurasia; this fungus typically occurs in clusters in compost, straw, or manure. Its brittle cups can have ragged edges.

1–3 in
2.5–7.5 cm

CELLAR CUP
Peziza cerea
F: Pezizaceae
Found across North America and Eurasia; this fungus often occurs on damp brickwork. It is dark ocher on the inside and pale outside.

1/2–2 3/4 in
1.5–7 cm

BAY CUP
Peziza badia
F: Pezizaceae
One of many similar species, this common fungus of North American and Eurasian woods has a spore-producing inner surface. Its brown cup develops an olive tint with age.

EUROTIALES

Better known for the blue and green molds, this order includes the fungi *Penicillium* (famous for producing penicillin, the first discovered antibiotic) and *Aspergillus* (a significant cause of disease in humans).

PERIGORD TRUFFLE
Tuber melanosporum
F: Tuberaceae
This highly prized truffle grows underground around oaks in the Mediterranean region; the truffles are found using dogs or pigs.

WHITE TRUFFLE
Tuber magnatum
F: Tuberaceae
Prized in Italy and France, this expensive truffle of alkaline soil in southern Europe can be cultivated on suitable host trees such as oak and poplar, by inoculation.

SUMMER TRUFFLE
Tuber aestivum
F: Tuberaceae
Found across southern and central Europe; this highly valued truffle grows underground, near a variety of broadleaf trees.

SCARLET ELFCUP
Sarcoscypha austriaca
F: Sarcoscyphaceae
Found from winter to early spring on fallen branches in North America and Eurasia; this species has a scarlet cup contrasting with its pale outer surface.

WHITE SADDLE
Helvella crispa
F: Helvellaceae
Possibly poisonous, this species is common in mixed woods in North America and Eurasia; its thin, saddlelike cap sits on a fragile, ribbed stem.

ELFIN SADDLE
Helvella lacunosa
F: Helvellaceae
Found in mixed woods in North America and Eurasia; this common species has a lobed, dark cap on a gray, fluted, and columned stem.

FALSE TRUFFLE
Elaphomyces granulatus
F: Elaphomycetaceae
Common in sandy soil below conifers in North America and Eurasia; this reddish brown truffle has a roughened surface and purple-black inner spore mass.

RHYTISMATALES

Commonly called tar spot fungi, the species in this order infect plant matter, such as leaves, twigs, bark, female conifer cones, and occasionally berries. Many species attack the needles of conifers, causing needle drop. The tar spot of maple leaves is perhaps the most frequently seen.

TAR SPOT
Rhytisma acerinum
F: Rhytismataceae
Abundant on acer or maple trees in North America and Eurasia; this fungus causes irregular spots, with paler yellow margins, which disfigure the leaves.

YELLOW FAN
Spathularia flavida
F: Cudoniaceae
This common species grows in wet, mossy conifer woods of N. America and Eurasia; it has flattened, pale to darker yellow, rubbery heads.

TAPHRINALES

This order contains many plant parasites, with most species in the genus *Taphrina*. All species have two growth states: in the saprophytic state, they are yeastlike and propagate by budding; but in the parasitic state, they emerge through plant tissues, causing distorted leaves and galls.

BIRCH BESOM
Taphrina betulina
F: Taphrinaceae
Found across Eurasia; this common species causes witches' broom, a disease of birch trees that causes clumps of narrow twigs to grow at branch ends.

PEACH LEAF CURL
Taphrina deformans
F: Taphrinaceae
This fungus infects most varieties of peach and nectarine trees in North America and Eurasia. The affected leaves curl and crinkle, and frequently turn reddish purple.

PLEOSPORALES

Typical members of this order develop their asci within a flasklike fruiting body. The asci have two wall layers: at maturity, the inner wall protrudes beyond the outer wall, ejecting the spores. Many species grow on plants; some form lichens.

PEAR SCAB
Venturia pyrina
F: Venturiaceae
Found in pear orchards in North America and Eurasia; this common parasite causes the fruit to distort, discolor, and even drop before it is ripe.

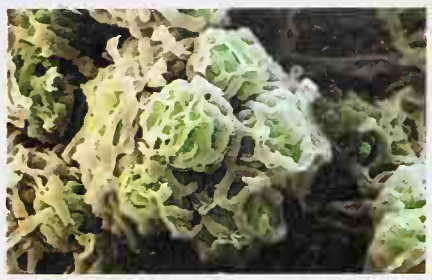
LEPTOSPHAERIA ACUTA
F: Leptosphaeriaceae
Found in North America and Eurasia, this common species infects the dead stems of the stinging nettle, *Urtica dioica*. It forms tiny cones that push through the stem surface of the host in order to eject its spores.

BOERHAVIA HEDERICOLA
F: Didymellaceae
Found in North America and Eurasia, this species causes circular white lesions on the leaves of the ivy plant, which turn brown and die.

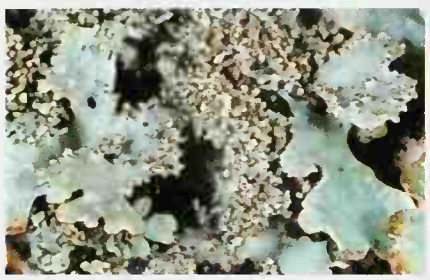
LICHENS

From outcrops of rock exposed to the sea to desert areas where the only place they can grow is inside the rock itself, lichens survive in the harshest parts of the world. They are some of nature's pioneers, creating foundations on which others can live.

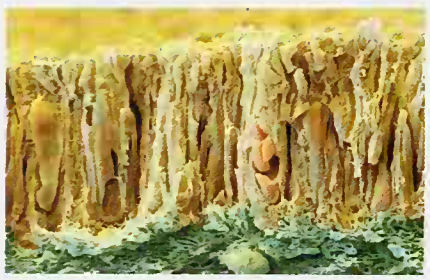
PHYLA	ASCOMYCOTA BASIDIOMYCOTA
CLASSES	10
ORDERS	15
FAMILIES	40
SPECIES	About 18,000



Asexual soredia are bundles of fungal hyphae (filaments) and algal cells. Here they are budding off and awaiting dispersal.



Asexual isidia are tiny peglike cells on the edge of the lichen, which break off to form new colonies of lichen.



Lichen cells are shown here in microscopic cross section. Spore-producing asci rise from algal cells.

DEBATE

UNLIKELY PARTNERS?

Lichen evolution remains a mystery. Scientists are still trying to understand how and why fungi and algae came to live together. It may have started as an attack by one on the other, which developed into a partnership. Not all lichen associations are necessarily mutually beneficial—some may be parasitic rather than a partnership.

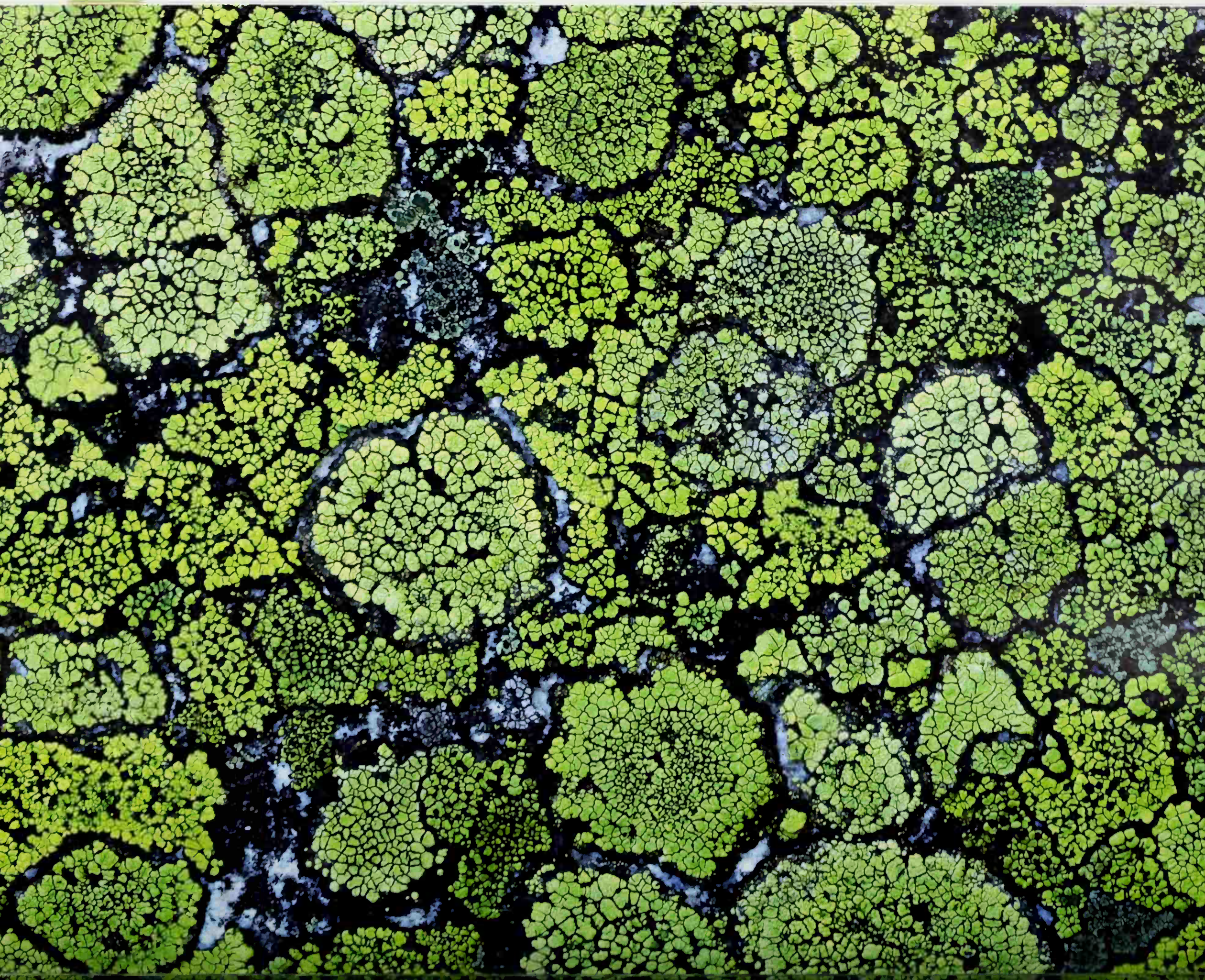
A lichen is not a single organism, but a composite consisting of a green alga or cyanobacterium and a fungus, living together in a mutually beneficial association. The algal partner provides nutrients through photosynthesis, while the fungal partner aids the alga by retaining water and capturing mineral nutrients. The fungus is normally a member of the Ascomycota (the sac fungi), or, more rarely, of the Basidiomycota (mushrooms)—lichen classification reflects the type of fungus involved. Typically, the fungus surrounds the photosynthetic cells of the alga, enclosing them within special fungus tissues unique to lichens. It appears that although neither partner is capable of surviving on its own, together they can endure the most extreme conditions. Lichens have even been found some 250 miles (400 km) from the South Pole, but they also grow in familiar places, such as dry-stone walls, rocks, and bark.

Lichens broadly fall into three types, based on shape: foliose lichens, which have leaves; crustose lichens, which form a crust; and fruticose lichens, which have branches. However, there are some that defy this categorization, such as filamentous (hairlike) and gelatinous (water-absorbent) lichens.

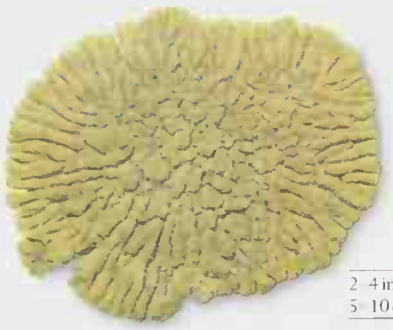
REPRODUCTION

Many lichens reproduce sexually by means of spores. These are produced by the fungal half of the partnership and are usually formed in special cup- or disklike structures called apothecia. These spores, once ejected, must land next to a suitable algal partner if they are to form another lichen and survive. Other lichens produce spores inside special chambers called perithecia, which are like microscopic volcanoes, releasing their spores through a hole at the top. Alternatively, lichens may reproduce asexually by budding or breaking off specialized parts of their body. These soredia or isidia contain a mix of fungal and algal cells, which, if they land in a suitable habitat, will go on to form new lichen colonies. Rocky shorelines in North America are home to vast colonies of lichens several miles in length. These will have taken hundreds or even thousands of years to spread to such a huge size.

SPREADING MAP LICHEN >
Typical of lichens, *Rhizocarpon* is able to colonize harsh environments such as dry, exposed rock surfaces.



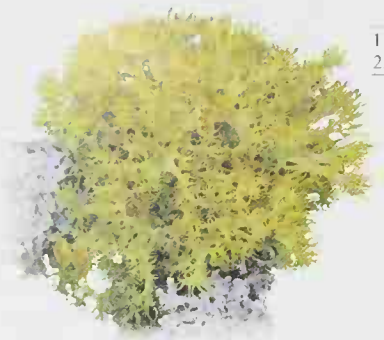
» LICHENS



2–4 in
5–10 cm

ORANGE LICHEN
Caloplaca verruculifera
F: Teloschistaceae

This lichen has radiating lobes with apothecia (spore-producing discs) at the center. It is found on rocks in coastal areas in North America and Eurasia, often near bird perches.



1–3 in
2.5–7.5 cm

GOLDEN-EYE LICHEN
Teloschistes chrysophthalmus
F: Teloschistaceae

A critically endangered species in America, Eurasia, and the tropics; this lichen grows on shrubs and small trees in old orchards and hedgerows. Its branched lobes produce large, orange discs.

1–3 in
2.5–7.5 cm

rounded lobes that lift at edges

COMMON WALL LICHEN
Xanthoria parientina
F: Teloschistaceae

Growing on trees, walls, and roofs in North America, Eurasia, Africa, and Australia; this lichen has rounded, yellow-orange lobes.

2–6 in/5–15 cm

BEARD LICHEN
Usnea filipendula
F: Parmeliaceae

Found mainly in northern regions; this species forms green-gray, pendent clumps on trees. Spiny apothecia form at the tips.

1–3 in
2.5–7.5 cm

REINDEER MOSS
Flavocetraria nivalis
F: Parmeliaceae

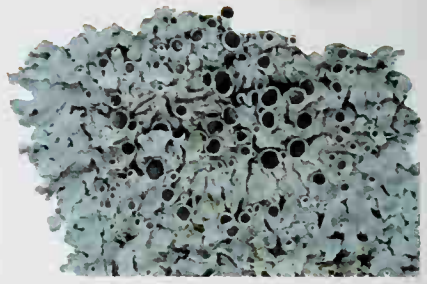
Found in mountain meadows and upland moors in North America and Eurasia; this species has brownish, flattened leafy fronds with spiny margins.

1–3 in
2.5–7.5 cm

HAMMERED SHIELD LICHEN
Parmelia sulcata
F: Parmeliaceae

This lichen's flattened lobes are gray-green, with rounded tips and powdery, reproductive structures on the surface. It is commonly found on trees in North America and Eurasia.

1–3 in
2.5–7.5 cm

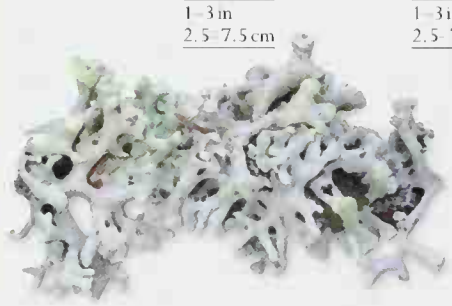


HOARY ROSETTE LICHEN
Physcia aipolia
F: Physciaceae

Growing on tree bark in the Americas and Eurasia; this gray to brownish gray species forms rough patches with a lobed margin. It has black apothecia.

1–3 in
2.5–7.5 cm

1–3 in
2.5–7.5 cm

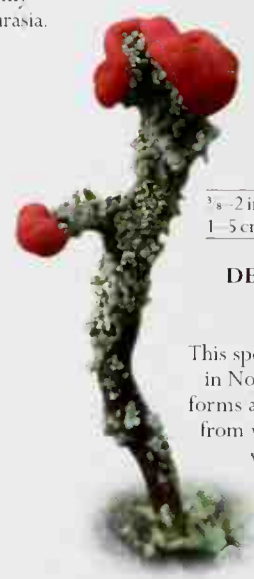


POWDER-HEADED TUBE-LICHEN
Hypogymnia tubulosa
F: Parmeliaceae

Common on twigs and tree trunks, this lichen has lobes that are gray-green above and dark underneath. It is found in North America and Eurasia.

HOODED TUBE-LICHEN
Hypogymnia physodes
F: Parmeliaceae

Found worldwide on trees, rocks, and walls, this lichen has pale gray-green lobes with wavy margins. The rare apothecia are red-brown with gray margins.



$^{3}/_{8}$–2 in
1–5 cm

DEVIL'S MATCHSTICK
Cladonia floerkeana
F: Cladoniaceae

This species is common in peaty soil in North America and Eurasia; it forms a crust of greenish gray scales from which stalks emerge, tipped with scarlet apothecia.

1–5 in
2.5–12.5 cm

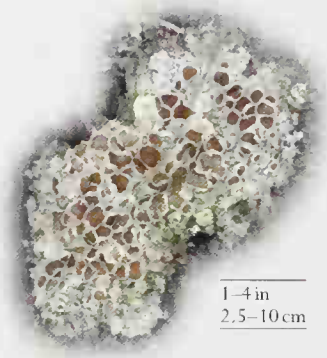
CARTILAGE LICHEN
Ramalina fraxinea
F: Ramalinaceae

Growing on trees in North America and Eurasia; this species forms flattened, gray-green branches dotted with apothecia.

1–4 in
2.5–10 cm

CORAL LICHEN
Sphaerophorus globosus
F: Sphaerophoraceae

Found on rocks in mountainous areas of North America and northern Eurasia; this fungus forms dense cushions of pinkish brown branches with globular apothecia.



1–4 in
2.5–10 cm

BLACK SHIELDS
Tephromela atra
F: Mycoblastaceae

This lichen has pale gray crustose lobes that look like dried oatmeal. Its apothecia are black. The lichen is found on exposed rocks in North America and Eurasia.

1–4 in/2.5–10 cm

STONEWALL RIM-LICHEN
Lecanora muralis
F: Lecanoraceae

This lichen often grows on concrete and on rocks. Its gray-green lobes radiate outward. It is found in North America and Eurasia.

1–4 in
2.5–10 cm

REINDEER LICHEN
Cladonia portentosa
F: Cladoniaceae

One of several reindeer lichens, this species is common in meadows and moorland in N. America and Eurasia. Its thin, hollow branches repeatedly divide.

2–20 in
5–50 cm

BLACK TAR LICHEN
Verrucaria maura
F: Verrucariaceae

Occurring on rocks along seacoasts in North America and Eurasia; this species has a dark gray, cracked crust that contains apothecia.

8–12 in
20–30 cm

DOG LICHEN
Peltigera praetextata
F: Peltigeraceae

Found on rocks in North America and Eurasia; this lichen has large gray-black lobes, with paler margins and reddish brown apothecia.

1–2 in
2.5–5 cm

BLISTERED JELLY LICHEN
Collema furfuraceum
F: Collemataceae

This lichen has flat, gelatinous, wrinkled lobes. It is found on rocks and trees in areas with high rainfall in North America and Eurasia.

green lobes spread out from center

2–6 in
5–15 cm

TREE LUNGWORT
Lobaria pulmonaria
F: Lobariaceae

Mainly found on tree bark in coastal areas in North America, Eurasia, and Africa; this species is declining due to habitat loss. The branching lobes are pale orange underneath.

2–8 in
5–20 cm

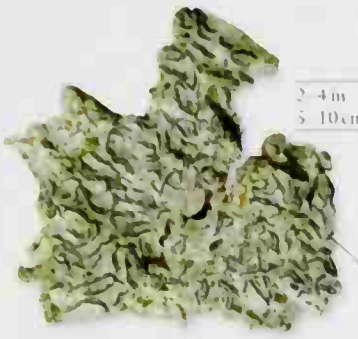
ROCK TRIPE
Lasallia pustulata
F: Umbilicariaceae

This North American and Eurasian lichen forms colonies on nutrient-rich rocks in coastal or upland areas. It has a gray-brown upper surface with many oval pustules.

1–3 in
2.5–7.5 cm

PETALLED ROCK-TRIPE
Umbilicaria polyphylla
F: Umbilicariaceae

A common species on rocks in mountains in North America and Eurasia; it has smooth, broad lobes that are dark brown above and black beneath.

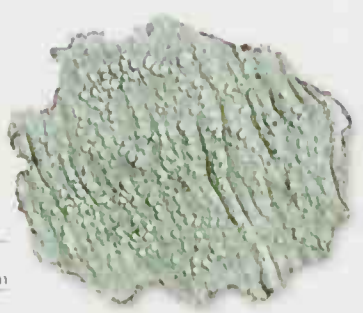


2–4 in
5–10 cm

black, slitlike openings release spores

COMMON SCRIPT LICHEN
Graphis scripta
F: Graphidaceae

Often seen on tree bark in North America and Eurasia; this lichen forms a thin, gray-green crust with slitlike openings.



1–3 in
2.5–7.5 cm

PERTUSARIA PERTUSA
F: Pertusariaceae

Common on tree bark in North America and Eurasia; this lichen forms gray crusts with a pale margin. The crusts are covered with groups of warts with tiny openings.

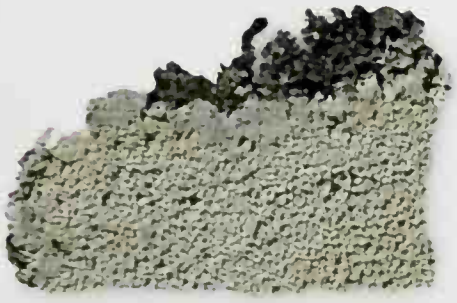
1–4 in
2.5–10 cm

LECIDEA LICHEN
Lecidea fuscoatra
F: Lecideaceae

This species is common on siliceous rocks and old brick walls in North America and Eurasia. It forms a gray, cracked crust, with sunken, black apothecia.

MAP LICHEN
Rhizocarpon geographicum
F: Rhizocarpaceae

Common on rocks in mountains in northern regions and Antarctica; this lichen forms a flat patch bordered by a black line of spores. Groups of these lichens have a patchwork appearance.



2–8 in
5–20 cm

dome-shaped apothecia

CRAB-EYE LICHEN
Ochrolechia parella
F: Ochrolechiaceae

This lichen forms patches on walls and rocks in North America and Eurasia; its surface usually has many pink-brown apothecia.

1–5 in
2.5–12.5 cm

BAEOMYCES RUFUS
F: Baeomycetaceae

Forming gray-green crusts on sandy soil and rocks, this lichen has brown ball-like apothecia on stalks a few millimeters high. It is found in North America and Eurasia.

ANIMA

LS

Animals make up the largest kingdom of living things. Driven by the need to eat food, and to escape being eaten, they are uniquely responsive to the world around them. The vast majority are invertebrates, but mammals and other chordates often outclass them in size, strength, and speed.

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INVERTEBRATES

Hugely varied in shape, invertebrates also have a wide range of lifestyles. Insects make up the largest group, but others include jellyfish, worms, and animals protected by hard shells.

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CHORDATES

Most of the world's large animals are chordates. Externally, they can be covered in fur, feathers, or overlapping scales, but internally nearly all have a backbone, which makes up part of a bony skeleton.

INVERTEBRATES

With nearly two million species identified, animals make up the largest kingdom of living things on Earth. The vast majority of them are invertebrates—animals without a backbone. Invertebrates are extraordinarily varied; many are microscopic, but the largest are over 33 ft (10 m) long.

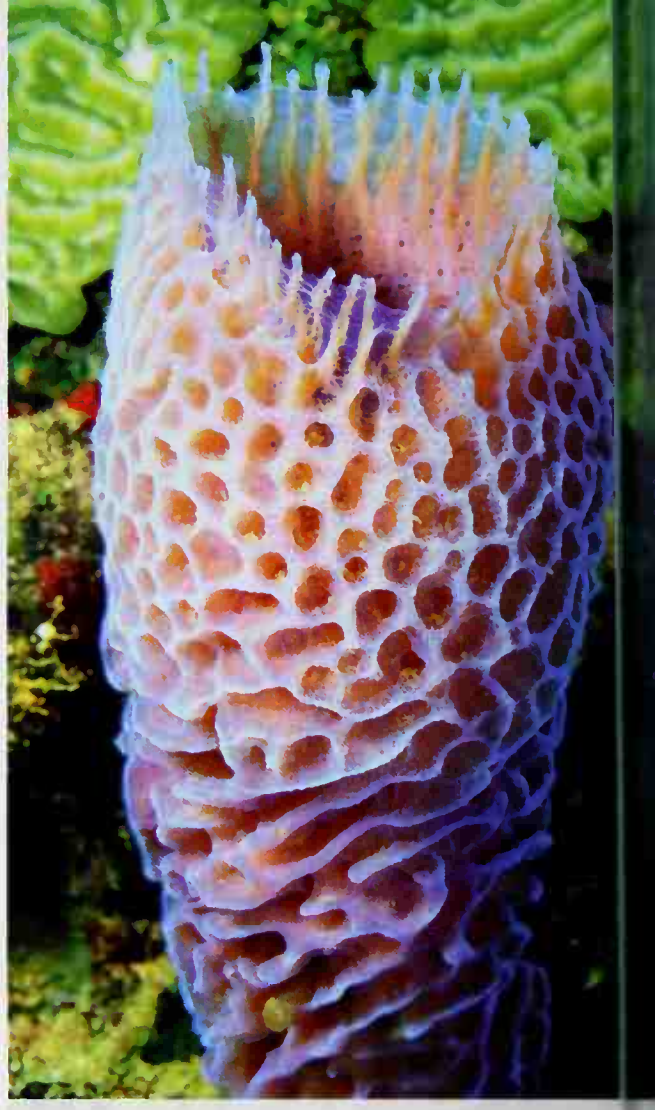
Invertebrates were the first animals to evolve. Initially, they were small, soft-bodied, and aquatic—features that many living invertebrates still share. During the Cambrian Period, which ended about 540 million years ago, invertebrates underwent a spectacular burst of evolution, developing a huge range of body forms and some very different ways of life. This evolutionary explosion produced almost all the major phyla, or groups, of invertebrates that exist today.

GREAT DIVERSITY

There is no such thing as a typical invertebrate, and many of the phyla have very little in common. The simplest kinds do not have heads or brains, and usually rely on internal fluid pressure to keep their shape. At the other extreme, arthropods have well-developed nervous systems and elaborate sense organs, including complex eyes. Crucially, they also have an external body case, or exoskeleton, with legs that bend at flexible joints. This particular body plan has proved to be remarkably successful, allowing arthropods to invade every natural habitat in water, on land, and in the air. Invertebrates also include animals with shells, and ones that are reinforced by mineral crystals or hard plates. However, unlike vertebrates, they never have internal skeletons made of bone.

SPLIT LIVES

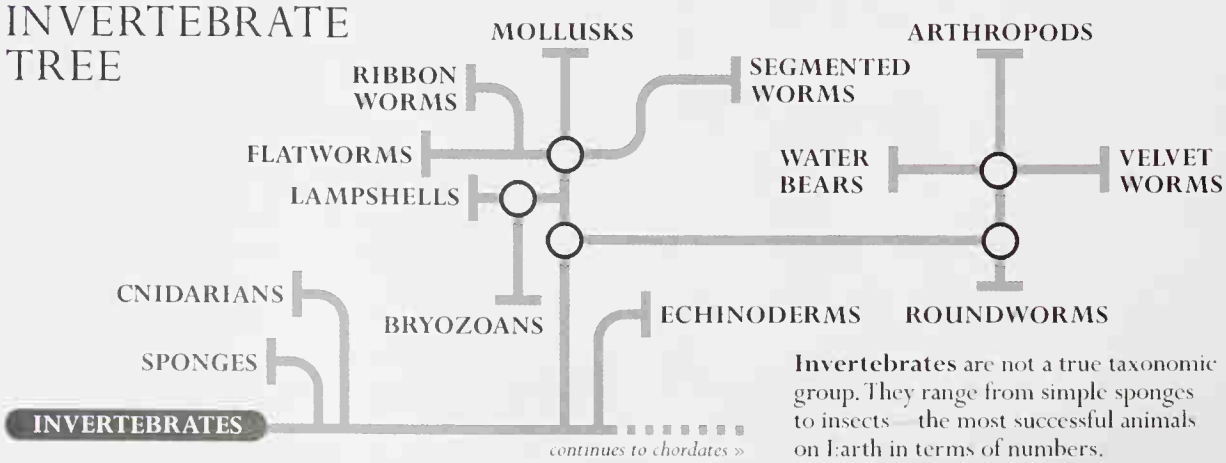
Most invertebrates begin life as eggs. Some look like miniature versions of their parents when they hatch, but many start life with a very different body form. These larvae change shape, food sources, and feeding methods as they grow up. For example, sea urchins have drifting larvae, which filter food from the sea, while the adults scrape algae from rocks. The change in shape—metamorphosis—can be gradual, or it can take place abruptly, with the young animal's body being broken down, and an adult body being assembled in its place. Metamorphosis enables invertebrates to exploit more than one food source, and it also helps them spread, often over great distances.



SPONGES
Among the simplest animals, sponges have sievelike bodies, with an internal skeleton of mineral crystals. Classified as the phylum Porifera, there are about 15,000 species.

ARTHROPODS
The phylum Arthropoda is the biggest in the animal kingdom, with over a million species identified. It includes insects, crustaceans, arachnids, centipedes, and millipedes.

INVERTEBRATE TREE



Invertebrates are not a true taxonomic group. They range from simple sponges to insects—the most successful animals on Earth in terms of numbers.

CNIDARIANS
Members of the phylum Cnidaria are soft-bodied invertebrates that kill their prey with stinging cells. Of 11,000 known species, the vast majority are marine.

FLATWORMS
Numbering about 20,000 species, the phylum Platyhelminthes contains animals with flat, paper-thin bodies, and a distinguishable head and tail.

SEGMENTED WORMS
With about 15,000 species, the phylum Annelida contains worms whose sinuous bodies are divided into ringlike segments. It includes earthworms and leeches.

CRUSTACEANS
Mainly aquatic, crustaceans are arthropods that breathe with gills. Classified as the subphylum Crustacea, there are over 50,000 species, including crabs and lobsters.

MOLLUSKS
One of the most diverse invertebrate groups, the phylum Mollusca contains about 110,000 species. They include gastropods, bivalves, and cephalopods.

ECHINODERMS
Recognizable by their five-fold symmetry, members of the phylum Echinodermata have skeletons of small, chalky plates set in their skin. There are about 7,000 species.

SPONGES

Simple, mostly marine animals, adult sponges live permanently attached to rocks, corals, and shipwrecks. A few species live in freshwater.

The Porifera vary in size and shape, from thin sheets to huge barrels, but all have the same basic structure: different types of specialized cells, but no organs. A system of water canals branches through the sponge, and water is drawn into them through tiny pores in the sponge's surface. Special chambers or cells lining the water canals trap and engulf bacteria from plankton for food, and waste water exits through large openings called osculae.

Many sponges are classically "spongy," others are rock hard, soft, or even slimy depending on the supporting skeleton, which is made up of tiny spicules of silicon dioxide or calcium carbonate. Spicules vary in shape and number between species and can be used in identification.

PHYLUM	PORIFERA
CLASSES	3
ORDERS	24
FAMILIES	127
SPECIES	About 15,000

CALCAREOUS SPONGES

The skeleton of Calcarea is composed of densely packed, mostly starlike, calcium carbonate spicules, each with three or four pointed rays. Variable in shape and crunchy to the touch, most species are small and lobe- or tube-shaped.

3¼ in
8 cm

LEMON SPONGE
Leucetta chagosensis
F: Leucettidae

Growing on steep coral reefs in the western Pacific, this sachike sponge provides a splash of bright color.

⅜–1½ in
1–4 cm

CLATHRINA CLATHRUS
F: Clathrimidae

Made up of many tubes, each only a few millimeters wide, this northeastern Atlantic sponge is a distinctive yellow color.

1¾–2 in/2–5 cm

PURSE SPONGE
Sycon ciliatum
F: Sycettidae

This simple, hollow sponge of northeast Atlantic coasts has spiky calcareous spicules surrounding its osculum.

4 in
10 cm

LEUCONIA NIVEA
F: Baeriidae

The shape of this northeastern Atlantic sponge varies from lobes and cushions to crusts. It grows in areas of high water movement.

3¾ in
8 cm

RED PURSE SPONGE
Grantessa sp.
F: Heteropiidae

Shaped like a small gourd, this delicate sponge grows between coral heads on shallow reefs in Malaysia and Indonesia.

DEMOSPONGES

Ninety-five percent of all Demospongiae fall into this group. Although they are varied in appearance, most have a skeleton made up of scattered silicon dioxide spicules and a flexible organic collagen called spongin. A few encrusting species have no skeleton and some have only spongin.

3¾ ft
1 m

BROWN TUBE SPONGE
Agelas tubulata
F: Agelasidae

This sponge consists of uneven brown tubes arranged in clusters. It is common on deep reefs in the Caribbean and Bahamas.

3¾ ft
1 m

BLUE SPONGE
Haliclona sp.
F: Chalinidae

One of very few blue-colored sponges, this species commonly grows on the tops of corals and rocks off northern Borneo.

14 in
35 cm

MEDITERRANEAN BATH SPONGE
Spongia officinalis adriatica
F: Spongiidae

This sponge has a pliable elastic skeleton, which retains its shape after it has been cleaned and dried. It is used for washing.

2–4 in
5–10 cm

ELEPHANT HIDE SPONGE
Pachymatisma johnstonia
F: Geodiidae

Mounds of this tough sponge can cover large areas of rocks and wrecks in clear coastal waters of the northeast Atlantic.

GOLF BALL SPONGE
Paratetilla bacca
F: Tetillidae

One of many tropical ball-shaped sponges, this species grows on sheltered coral reefs in the western Pacific.

4¾ in/12 cm

12–16 in
30–40 cm

RED TREE SPONGE
Negombata magnifica
F: Podospongiidae

Attempts to farm this beautiful Red Sea sponge are meeting with some success. It contains chemicals of potential medical importance.

20 in
50 cm

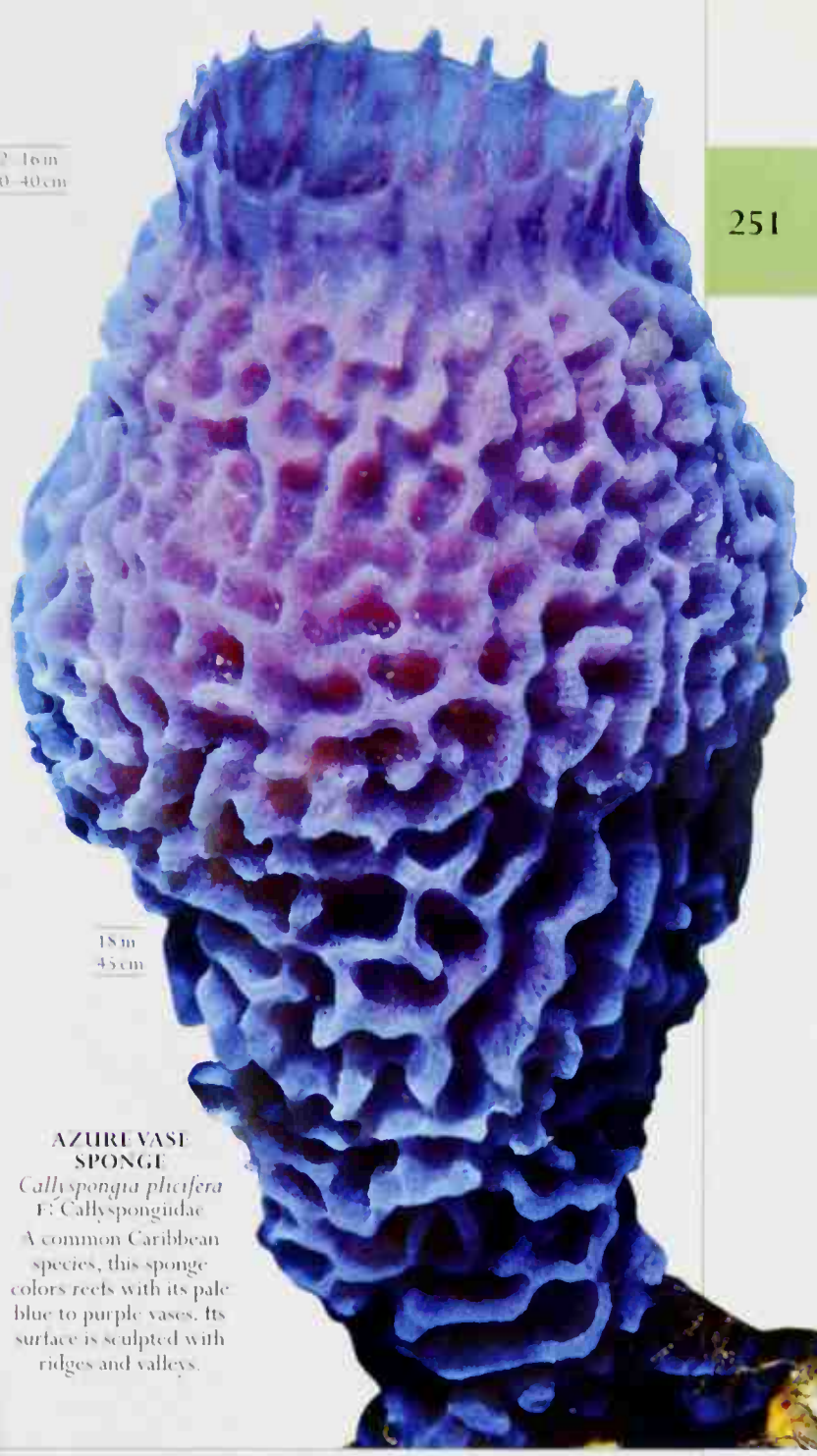
BORING SPONGE
Cliona celata
F: Clionaidae
Although it appears as yellow lumps, much of this European sponge remains hidden as strands growing through shells and calcareous rocks.

6–12 in
15–30 cm

BORING SPONGE
Cliona delitrix
F: Clionaidae
Water leaves this Caribbean sponge through large holes called oscula (shown here). This sponge bores through corals by secreting acid.

12–16 in
30–40 cm

YELLOW FINGER SPONGE
Callyspongia ramosa
F: Callyspongiidae
The bright color of this tropical Pacific sponge is due to the chemicals it contains. Sponge extracts are used by the pharmaceutical industry.



18 in
45 cm

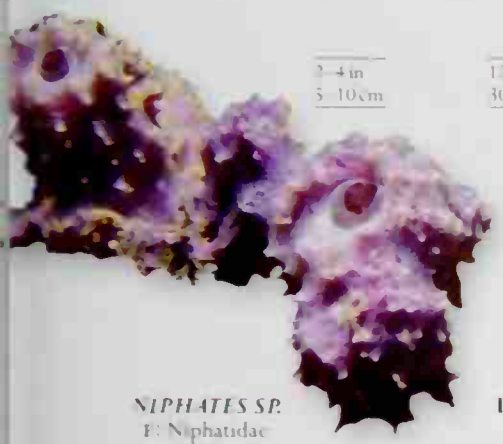
AZURE VASE SPONGE
Callyspongia pfeifera
F: Callyspongiidae
A common Caribbean species, this sponge colors reefs with its pale blue to purple vases. Its surface is sculpted with ridges and valleys.

12 in
30 cm

BREADCRUMB SPONGE
Halichondria panicea
F: Halichondriidae
This northeastern Atlantic sponge grows as crusts on rocky shores and in shallow water. Its color comes from symbiotic algae.

½–2 in
1–2 cm

SPIRASTRELLA CUNCTATRIX
F: Spirastrellidae
One of many colorful encrusting sponges found in the ocean, this species covers inshore rocks in the Mediterranean and North Atlantic.



3–4 in
5–10 cm

NIPHATES SP.
F: Niphatidae
Like many sponges, this tropical species grows as irregular lumps and crusts. Its surface is covered in small projections called conuli.

12 in
30 cm

PINK VASE SPONGE
Niphates digitalis
F: Niphatidae
The shape of this Caribbean reef sponge varies from a tube to an open vase. Small anemones often grow on its rough surface.

6–8 ft
2 m

BARREL SPONGE
Xestospongia testudinaria
F: Petrosiidae
Small fish and many invertebrates live on and in this huge Indo-Pacific sponge, which grows big enough for a person to fit inside.

4 in
10 cm

ELK HORN SPONGE
Axinella damicornis
F: Axinellidae
This common bright yellow Mediterranean sponge also grows on steep rock faces on Irish coasts and on the west coast of Great Britain.

APLYSINA ARCHERI
F: Aplysinidae
The graceful long tubes of this sponge sway gently with the current on the Caribbean reefs where it grows.

2½–6½ ft
0.8–2 m

GLASS SPONGES

Hexactinellida are a small group of sponges lives mostly in the deep ocean, where some form reeflike mounds up to 65 ft (20 m) high. The six-rayed, starlike, silica spicules that make up the skeleton are usually fused together as a rigid lattice. After death, the skeleton remains as a ghostly outline.

19–32 in
48.5–80.5 cm

DEEP SEA GLASS SPONGE
Hyalonema sieboldi
F: Hyalonematidae
This glass sponge lives in the deep sea, and is kept clear of the mud by its long thin stalk of silica spicules.

13½ in
35 cm

VENUS'S FLOWER BASKET
Euplectella aspergillum
F: Euplectellidae
Growing in tropical oceans below about 500 ft (150 m), this sponge was collected and displayed by Victorians for its delicate silica skeleton.

CNIDARIANS

This phylum includes jellyfish, corals, and anemones. They have stinging tentacles to catch live prey, which they digest in a simple saclike gut.

All cnidarians are aquatic and most are marine. They have two body plans: a free-swimming bell-like shape called a medusa—as seen in jellyfish—and a static polyp, typical of anemones. Neither medusae nor polyps have a head or front end. Their tentacles encircle a single gut opening, used to take in food and to eliminate waste.

A cnidarian's nervous system consists of a simple network of fibers; there is no brain. This means that the animal's behavior is usually simple. Although they are carnivorous, cnidarians cannot actively pursue their prey, with the possible exception of the box jellyfish. Instead, most species wait for swimming animals to blunder into the reach of their tentacles.

STINGS

Cnidarians' outer skins—and in some species the inner skin as well—are peppered with tiny stinging capsules of a kind that is unique to animals of this phylum. These stinging organs are called cnidocysts (or cnidocytes), and it is from these that cnidarians get their name. Cnidocysts are concentrated on the tentacles, and are triggered by touch or chemical signals, both when the animal comes into contact with potential prey and when it is under attack. Each cnidocyst contains a microscopic sac of venom and discharges a tiny coiled "harpoon" to inject the venom into flesh. Some stings can penetrate human skin and inflict severe pain, but the vast majority of cnidarians are harmless to humans.

ALTERNATING LIFE CYCLE

Many cnidarians have a life cycle that alternates between medusa and polyp—usually with one of these forms dominating, although in some groups one or the other form is missing. The free-swimming medusa is normally the sexual stage. In most species fertilization is external: sperm and eggs are released in open water, forming planktonic larvae that resemble tiny flatworms. These settle in order to grow into polyps. Specialized polyps then produce new medusae to complete the cycle.

PHYLUM	CNIDARIA
CLASSES	4
ORDERS	22
FAMILIES	278
SPECIES	11,300

This microscopic view shows cnidocysts (stinging cells) that have been triggered to discharge their venom-laden harpoons.

BOX JELLYFISH

Members of the class Cubozoa are found in tropical and subtropical waters. They differ from true jellyfish in having a greater ability to control the direction and speed of their movement, rather than drifting with the currents. A flapping skirt at the bottom of the bell powers them at considerable speed.

Box jellyfish have eyes, set in clusters on the sides of their transparent bell. They can see enough to steer past obstacles and to spot prey.

bell controls speed

1–9¾ ft
0.3–3 m

SEA WASP
Chironex fleckeri
F: Chirodropidae

This Indo-Pacific species—the largest box jellyfish—delivers a particularly painful sting and has caused human fatalities.

TRUE JELLYFISH

The familiar jellyfish bell is the medusa stage of the Scyphozoa life cycle. The polyp is reduced, or in some deepwater forms, missing. Jellyfish polyps undergo strobilation, a process that produces new tiny medusae by budding. Rhizostome jellyfish lack a fringe of tentacles around the bell.

UPSIDE-DOWN JELLYFISH
Cassiopea andromeda
F: Cassiopeidae

8–12 in
20–30 cm

Superficially resembling an anemone, this Indo-Pacific rhizostome jellyfish lives at the bottom of lagoons, mouth upward, with its bell pulsating to circulate water.

4–8 in
10–20 cm

DEEP SEA CORONATE JELLYFISH
Periphylla periphylla
F: Periphyllidae

This is one of many little-known deepwater species in a group of jellyfish characterized by a bell with an encircling groove.

18–28 in
45–70 cm

WHITE-SPOTTED JELLYFISH
Phyllorhiza punctata
F: Mastigiidae

This rhizostome jellyfish is native to the western Pacific, but has been introduced to North America, where it may threaten commercial fisheries.

1½ in
4 cm

STALKED JELLY FISH
Haliclystus auricula
F: Lucernariidae

Although it lives more like a static polyp, this curious North Atlantic cnidarian, a possible cousin of box jellyfish, is in fact a medusa.

5½–6½ in
14–16 cm

8–16 in
20–40 cm

MOON JELLYFISH
Aurelia aurita
F: Ulmaridae

This globally widespread genus has four long "arms" as well as small marginal tentacles. It swarms to breed near coasts and polyps settle in estuaries.

SPOTTED LAGOON JELLYFISH
Mastigias papua
F: Mastigiidae

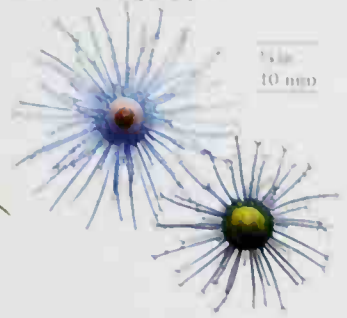
Like other rhizostome jellyfish, this algae-containing species traps planktonic food with mucus. It enters South Pacific lagoons, including those of oceanic islands.

HYDROZOANS

Most animals of the class Hydrozoa live as branching sea-dwelling colonies forming miniature polyp-bearing forests. Some anchor themselves to surfaces by creeping horizontal stems, called stolons. Colonies are supported by a horny translucent sheath and some of the polyps produce sexual medusae. Freshwater hydra lack medusae: instead, sex organs develop directly on solitary polyps.

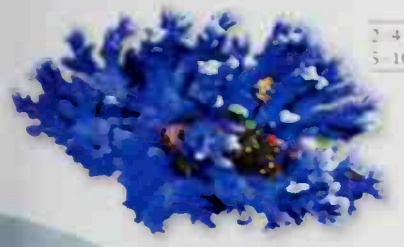
SNAILFUR
Hydractinia echinata
F: Hydractiniidae
O: Anthoathecata

One of a family of colonial spiny hydrozoans, this northeast Atlantic species grows on the surface of snail shells containing hermit crabs.



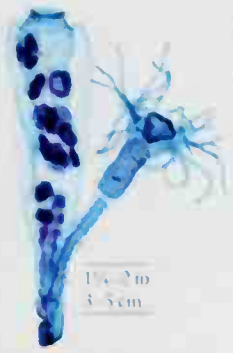
BLUE BUTTONS
Porpita porpita
F: Porpitidae
O: Anthoathecata

This colonial, jellyfish-like hydrozoan of tropical oceans is sometimes regarded as a highly modified individual polyp.



PURPLE LACE "CORAL" HYDROID
Distichopora violacea
F: Stylasteridae

Like some other hydrozoans, colonies of this Indo-Pacific lace coral have polyps specialized for different functions, such as feeding and stinging.



COMMON OBELIA
Obelia geniculata
F: Campanulariidae

This is a worldwide hydrozoan, abundant on intertidal seaweeds. It grows in zigzag colonies of cup-encased polyps that sprout from creeping horizontal stems.

EIGHT-RIBBED HYDROMEDUSA
Helicertum octocostatum
F: Helicertidae

This hydrozoan from the North Atlantic and North Pacific oceans belongs to a family related to those with cup-encased polyps. It is known mainly from medusae.

CUP HYDROMEDUSA
Phialella quadrata
F: Phialellidae

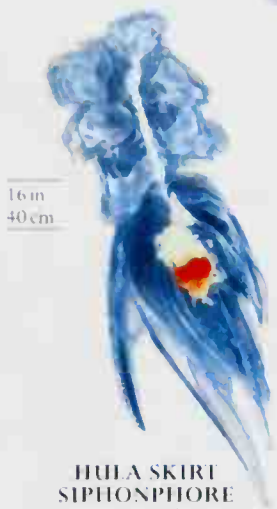
Like related *Obelia*, branching colonies of this globally widespread hydrozoan release free-living medusae, which reproduce sexually.

PORTUGUESE MAN OF WAR
Physalia physalis
F: Physaliidae

Resembling a jellyfish, this is really an ocean-going colony of hydrozoans. Stinging tentacles and specialized polyps are suspended from a gas-filled float.

FEATHER HYDROID
Aglaophenia cupressina
F: Aglaopheniidae

Feather hydroids and the closely related sea ferns belong to a group of colonial hydrozoans with cup-encased polyps. This is an Indo-Pacific species.



HULA SKIRT SIPHONPHORE
Physophora hydrostatica
F: Physophoridae

This widespread free-floating hydrozoan colony has a smaller float than its relative, the Portuguese man of war, and carries prominent swimming bells.

LION'S MANE JELLYFISH
Cyanea capillata
F: Cyaneidae

A large species of Arctic waters, this jellyfish has many tentacles arranged in dense groups. It has a powerful sting and its prey includes fish.

BLUE JELLYFISH
Cyanea lamarckii
F: Cyaneidae

A smaller cousin of the lion's mane jellyfish, this North Atlantic species has a milder sting. It preys on ctenophores and other medusae.

PINK-HEARTED HYDROID
Tubularia sp.
F: Tubulariidae

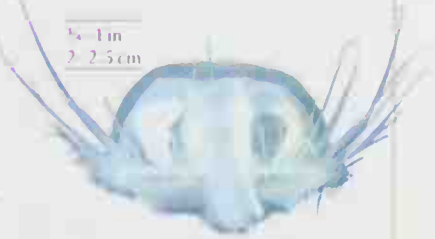
Tubularia hydrozoans have polyps on long stems with two whorls of tentacles, one around the polyp base and one around its mouth.

FIRE "CORAL" HYDROID
Millepora sp.
F: Milleporidae

Like others of its family, this fiercely stinging colonial hydrozoan has a calcified skeleton and is a reef-builder. It is distantly related to true stony corals.

COMMON HYDRA
Hydra vulgaris
F: Hydridae

Lacking the medusa stage, hydras have small freshwater polyps that can reproduce asexually by budding. This is a globally widespread cold-water species, shown here in enhanced color.

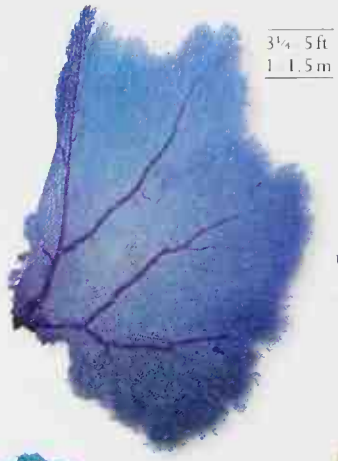


FRESHWATER JELLYFISH
Craspedacusta sowerbyi
F: Olindiasidae

Sporadic in freshwater ponds, lakes, and streams worldwide, minute polyps of this animal develop into dominant medusae.

ANEMONES AND CORALS

Unlike other cnidarians, the Anthozoa lack the free-swimming medusa stage altogether and most remain static throughout their life cycle. The polyps, many of which have a flowerlike appearance, produce sperm and eggs. Members of this class include solitary anemones, colonial sea pens, soft corals, and tropical reef-forming stony corals.

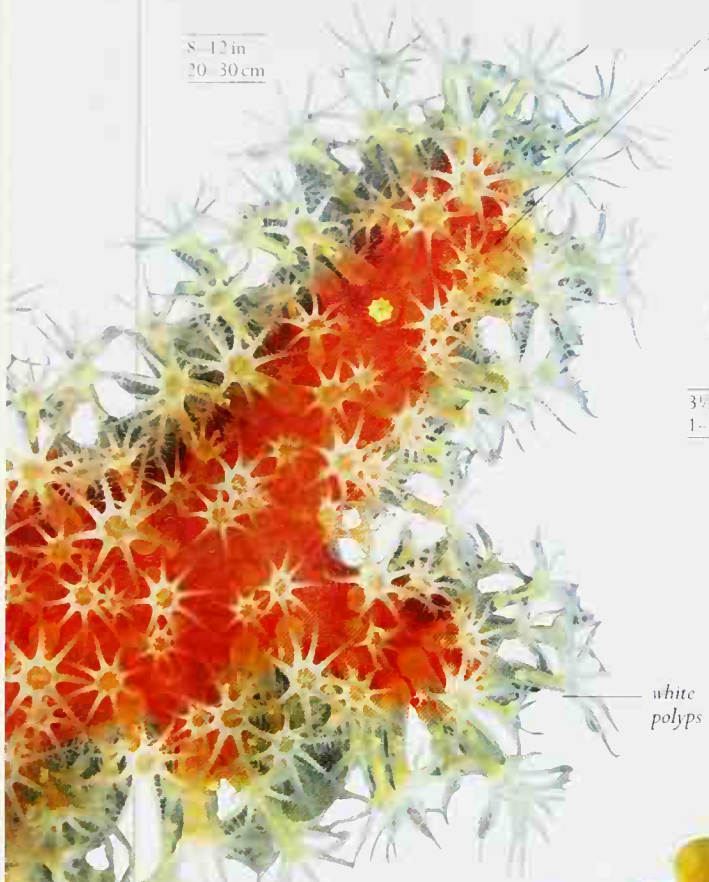


COMMON SEA FAN
Gorgonia ventalina
F: Gorgoniidae

Sea fans, such as this Caribbean species, have upright fanlike colonies supported by a central axis, which is stiffened with a horny substance called gorgonin.

CARNATION CORAL
Dendronephthya sp.
F: Nephtheidae

Typical of a family of stalked soft corals with polyps arranged in clusters, this colorful species occurs on Indo-Pacific tropical reefs.



RED DEAD-MAN'S FINGERS
Alcyonium glomeratum
F: Alcyoniidae

This is a more slender, upright ally of dead-man's fingers, found on sheltered rocky European coastlines. The color varies from red to yellow.

TOADSTOOL LEATHER CORAL
Sarcophyton trocheliophorum
F: Alcyoniidae

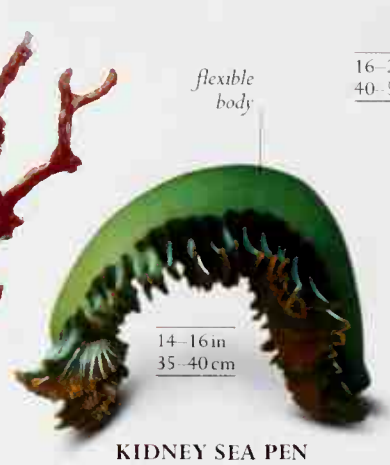
This soft coral can form enormous leathery colonies on tropical reefs of the Indo-Pacific. It is fast-growing, nourished by photosynthetic algae.

SEA STRAWBERRY
Gersemia rubiformis.
F: Nephtheidae

This stalked soft coral forms bright pink lumpy colonies. It occurs in northern parts of the Pacific and Atlantic Oceans.

RED CORAL
Corallium rubrum
F: Coralliidae

Colonies of this Mediterranean sea fan (not a true coral) are supported by a skeleton of tiny, enmeshed calcified needles. It is valued for jewelry.



KIDNEY SEA PEN
Sarcoptilus grandis
F: Pennatulidae

Widespread in temperate waters, this sea pen has kidney-shaped branches that occur in rows along each side of its body.

ORANGE SEA PEN
Ptilosarcus gurneyi
F: Pennatulidae

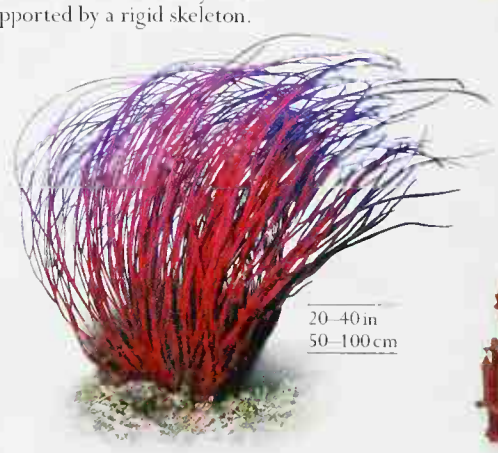
One of many brightly colored sea pens, this species from the Pacific coast of North America retracts into its burrow when disturbed by predators.

COMMON DEAD-MAN'S FINGERS
Alcyonium digitatum
F: Alcyoniidae

A typical soft coral, this thickly lobed European species has colonies of polyps, which are carried on a fleshy mass unsupported by a rigid skeleton.

WHITE SEA WHIP
Junceella fragilis
F: Ellisellidae

Sea whips are threadlike relatives of sea fans, with their supporting horny axis reinforced with calcium. This is an Indonesian reef species.



RED SEA WHIP
Ellisella sp.
F: Ellisellidae

Ellisella sea whips form two-prong branching colonies, some of which may form dense underwater bushes. They occur in tropical and temperate waters.

ORGAN PIPE CORAL
Tubipora musica
F: Tubiporidae

This Indo-Pacific soft coral has polyps in upright, calcified tubes, which are connected to the colony by a rootlike network at the base.

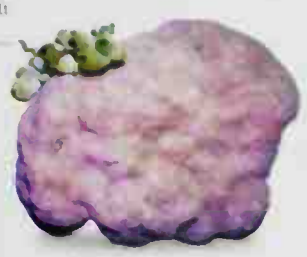
BLUE CORAL
Heliopora coerulea
F: Helioporidae

Despite its hard, calcified skeleton, this species is more closely related to soft coral than stony coral. It is the only member of its order.

4–8 in
10–20 cm

FLOWERPOT CORAL
Goniopora columna
F: Poritidae

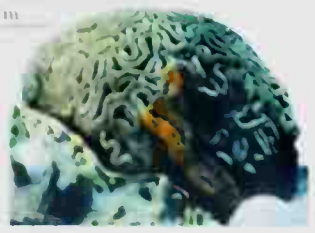
This species has daisylike polyps that are greatly lengthened when fully extended. It is an Indo-Pacific relative of the lobe coral.



15–16 ft
4–5 m

LOBE CORAL
Porites lobata
F: Poritidae

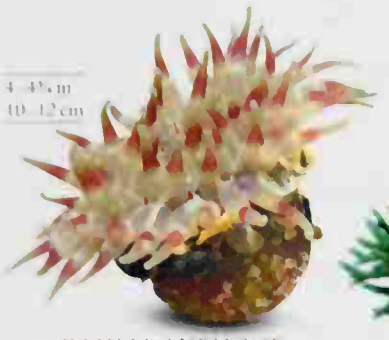
One of the most common reef-builders of the Indo-Pacific, this coral forms large encrusting colonies in places buffeted by strong wave action.



3½–6½ ft
1–2 m

LOBED BRAIN CORAL
Lobophyllia sp.
F: Mussidae

Massive colonies of this brain coral—either flattened or dome-shaped—occur on reefs in tropical waters of the Indo-Pacific.



4–4½ in
10–12 cm

DAHLIA ANEMONE
Urticina felina
F: Actinidae

Sticky swellings on this anemone may carry so much debris that, with tentacles retracted, it resembles a small pile of gravel. It occurs around the North Pole.

3½–9½ ft
1–3 m

STAGHORN CORAL
Acropora sp.
F: Acroporidae

The branching stag horn corals are among the largest tropical reef-builders. Nourished by photosynthetic algae, these species are fast growing.

3½ ft
1 m

DAISY CORAL
Goniopora sp.
F: Poritidae

Long-reaching polyps of *Goniopora* stony corals on tropical reefs typically have 24 tentacles. They are among the most flowerlike of corals.

3½–9½ ft
1–3 m

LARGE-GROOVED BRAIN CORAL
Colpophyllia sp.
F: Faviidae

The hemispherical bramble structure of this coral is typical of its family. It is a tropical reef-builder that contains photosynthetic algae.

4–8 in
10–20 cm

MUSHROOM CORAL
Fungia fungites
F: Fungiidae

This is one of many tropical mushroom corals that are not reef-building, but live among other species as solitary polyps crawling over the ocean floor.

20–40 in
50–100 cm

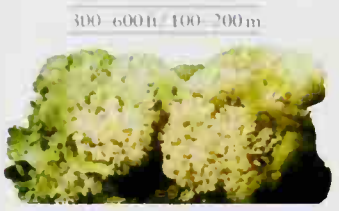
MAGNIFICENT SEA ANEMONE
Heteractis magnifica
F: Stichodactylida

This giant anemone is from Indo-Pacific reefs, where it lives in close partnership with a variety of fish species, including clown fish.

⅜–⅝ in
10–15 mm

DEVONSHIRE CUP CORAL
Caryophyllia smithii
F: Caryophyllidae

This northeastern Atlantic species belongs to a family containing cold water corals, some with large, anemone-like polyps. Barnacles frequently attach to it.



300–600 ft 100–200 m

ATLANTIC COLD WATER CORAL
Lophelia pertusa
F: Caryophyllidae

Unlike many deep sea corals lacking nutrient-supplying algae, this North Atlantic species forms extensive reefs, although only very slowly.

1–6 in
2.5–15 cm

PLUMOSE ANEMONE
Metridium senile
F: Metridiidae

This is a globally widespread member of a family of anemones that is characterized by a fuzzy mass of tentacles. It can split to form genetically identical populations.

2–2¾ in
5–7 cm

SNAKELOCKS ANEMONE
Anemonia viridis
F: Actiniidae

The conspicuously long tentacles of this common European intertidal anemone rarely retract, even when exposed at low tide.

4–6 in
10–15 cm

COMMON TUBE ANEMONE
Cerianthus membranaceus
F: Cerianthidae

Tube anemones burrow through sediment, using unique nonstinging cnidocysts to build felthike tubes from mucus. This species occurs on European offshore mud.

20–40 in
50–100 cm

ATLANTIC BLACK CORAL
Antipathes sp.
F: Antipathidae

Mostly found in deep waters, black corals consist of spiny polyp colonies encased in slender, horny exoskeletons.

FLATWORMS

Structurally among the simplest of animals, flatworms live wherever a moist habitat can provide their paper-thin bodies with oxygen and food.

Flatworms belong to the major phylum known as Platyhelminthes, and are found in various forms in the ocean, in freshwater ponds, or even within the bodies of other animals. Superficially resembling leeches, flatworms are in fact far simpler animals. With no blood system and no organs for breathing, they use their entire body surface to absorb oxygen from moisture outside. The smallest flatworms, which have no gut, also absorb their food in this way. In other species the gut has one opening but branches frequently, so that digested food can still reach all tissues, even without a blood stream to circulate the nutrients. Some free-living flatworms are detritus-eaters, gliding along on a bed of microscopic beating hairs. Others prey on other invertebrates.

INTERNAL PARASITES

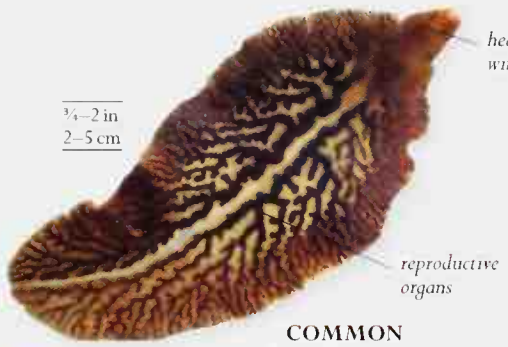
Tapeworms and flukes are parasites. Inside the host animal, their flattened, gutless bodies are perfectly suited for absorbing nutrients. Many have complex ways of passing from host to host and may infect more than one type of animal. They enter the body of the host in infected food or sometimes by penetrating the skin. Once inside, a parasite may go deeper into the body—burrowing through the gut wall to lodge in vital organs.

PHYLUM	PLATYHELMINTHES
CLASSES	5
ORDERS	33
FAMILIES	About 400
SPECIES	About 20,000

DEBATE

A NEW PHYLUM?

Traditionally, the tiny, gutless, and brainless marine animals called acoelans are viewed as flatworms. Controversial studies suggest that they belong in a new phylum of their own, which would make them the first with a "head" and a "tail," in contrast with radial (round) cnidarians.



COMMON LIVER FLUKE
Fasciola hepatica
F: Fasciolidae
Flukes typically have complex, parasitic life cycles. This species infects grass-eating cattle via freshwater snails, and feeds from the host's liver.

GIANT INTESTINAL FLUKE
Fasciolopsis buski
F: Fasciolidae
This East Asian species is one of the largest flukes to infect humans. It lives only in the upper intestine and does not enter other organs.

3 in
7.5 cm

PORK TAPEWORM
Taenia solium
F: Taeniidae
Tapeworms are intestinal parasites, but at an intermediate stage can invade muscle as cysts. This species lives in pigs, and may pass to humans in infected meat.

JACK FLUKE
Provitellus turrum
F: Monorchiidae
Provitellus flukes infect the guts of fish living on tropical reefs. This species has been recorded in jack fish.

CATTLE-SNORING BLOOD FLUKE
Schistosoma nasale
F: Schistosomatidae
This parasite is transmitted through freshwater snails. It infects cattle, causing nasal growths that make the cattle snore when breathing.

EPIZOIC FLATWORM
Waminoa sp.
F: Convolutidae
This coral-living species is one of many marine micro-flatworms that resemble planktonic larvae of cnidarians.

GIANT LEAF FLATWORM
Kaburakia excelsa
F: Stylochidae
Like other leaf flatworms, this North American intertidal species is mainly carnivorous. It smothers its prey with a mouth-bearing extension of its gut.

CANDY STRIPE FLATWORM
Prosthecereaeus vittatus
F: Euryleptidae
This animal belongs to a group of mainly marine, free-living, cross-fertilizing hermaphrodites called polyclads. It is an Atlantic Ocean species.

ROUNDWORMS

The simple, cylindrical roundworms are remarkably successful—surviving almost everywhere, resisting drought, and reproducing rapidly.

PHYLUM	NEMATODA
CLASSES	2
ORDERS	12
FAMILIES	About 160
SPECIES	About 20,000

The phylum Nematoda is ubiquitous. There can be millions of roundworms in a square metre of soil, and they also live in freshwater or marine habitats. Many are parasites. These worms, or nematodes, can be extraordinarily prolific, producing hundreds of thousands of eggs per day. When environmental conditions deteriorate they can survive heat, frost, or drought by enclosing themselves in a cyst and becoming dormant.

Roundworms have muscle-lined body cavity and two openings to their gut—the mouth and anus. Their cylindrical bodies are coated in a tough layer, called a cuticle—similar to that of arthropods—which they moult periodically as they grow.

BLACK AND YELLOW FLATWORM
Pseudoceros dimidiatus
F: Pseudocerotidae

Marine polyclads are large free-living flatworms. Many are strikingly colored, warning predators of their nasty taste. This species is from Indo-Pacific waters.

2½–3½ in / 7–8 cm

undulating margin

FLOWERS' FLATWORM
Pseudobiceros flowersi
F: Pseudocerotidae

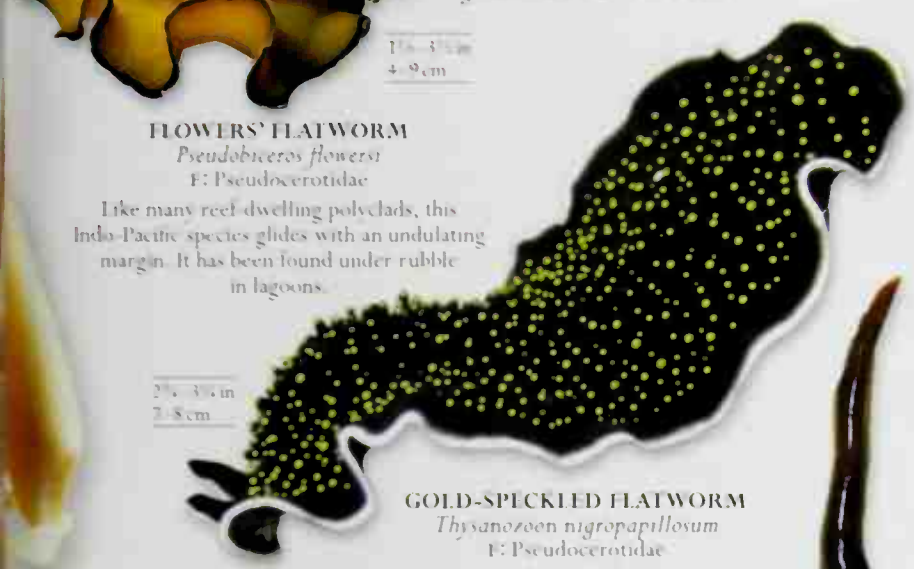
Like many reef-dwelling polyclads, this Indo-Pacific species glides with an undulating margin. It has been found under rubble in lagoons.

1½–3½ in / 4–9 cm

SHOVEL-HEADED LAND FLATWORM
Bipalium kewense
F: Bipalidae

Land flatworms are mostly tropical and must have damp conditions. This Asian species has been accidentally introduced to greenhouses around the world.

8–12 in / 20–30 cm



GOLD-SPECKLED FLATWORM
Thysanozoon nigropapillosum
F: Pseudocerotidae

Many *Thysanozoon* polyclads are coated with pimply swellings, which are yellow-tipped on this otherwise velvety black species of the Indo-Pacific.

2½–3½ in / 7–8 cm

4–6½ in / 10–17 cm

DRAB FRESHWATER FLATWORM
Dugesia lugubris
F: Planariidae

Triclads are flatworms with a triple-branched gut. This European species is one of many triclads found in freshwater habitats; others are marine.

¾–1¼ in / 1.5–2 cm

BROWN FRESHWATER FLATWORM
Dugesia tigrina
F: Planariidae

Native to freshwater habitats of North America, this species has been introduced to Europe.

½–1 in / 1–1.5 cm

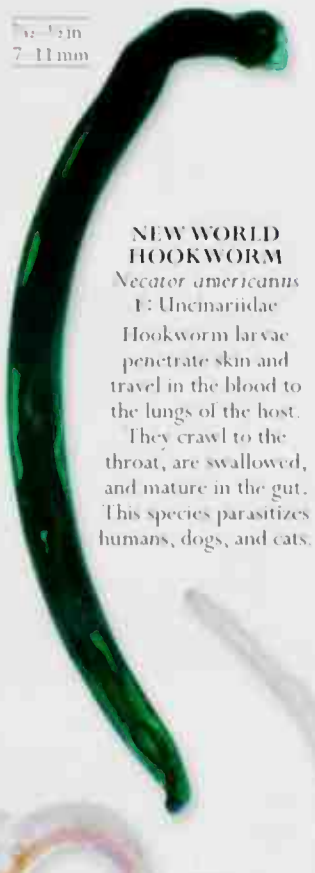
NEW ZEALAND LAND FLATWORM
Arthurdendyus triangulatus
F: Geoplanidae

This large soil-living species is native to New Zealand, but has invaded Europe. It preys on earthworms.

¾–1½ in / 2–3 cm

STREAM FLATWORM
Dugesia gonocephala
F: Planariidae

Many of the freshwater *Dugesia* flatworms, such as this European species of running water, have earlike flaps for detecting water currents.



NEW WORLD HOOKWORM
Necator americanus
F: Uncinariidae

Hookworm larvae penetrate skin and travel in the blood to the lungs of the host. They crawl to the throat, are swallowed, and mature in the gut. This species parasitizes humans, dogs, and cats.

1¼–2 in / 3–5 cm

COMMON WHIPWORM
Trichuris trichiura
F: Trichuridae

Like many other gut parasites, the mainly tropical whipworm infects humans who eat food contaminated with feces. It completes its life cycle in the intestines.

COMMON SOIL ROUNDWORM
Caenorhabditis elegans
F: Rhabditidae

This widespread, colorless, soil-living roundworm is used in research to further understanding of genetics and development.

1/30 in / 1 mm

1/30 in / 1 mm

SOYBEAN CYST ROUNDWORM
Heterodera glycines
F: Heteroderidae

This colorless, soil-living roundworm infects the roots of leguminous plants around the world, causing cysts and significantly reducing yields.

pale, cylindrical body

6–14 in / 15–35 cm

LARGE INTESTINAL ROUNDWORM
Ascaris sp.
F: Ascarididae

A common parasite of humans in regions of poor sanitation, this species enters the intestine in contaminated food before infecting the lungs.

SEGMENTED WORMS

With more complex muscle and organ systems than flatworms, many species of this phylum, called Annelida, are accomplished swimmers or burrowers.

Segmented worms include earthworms, ragworms, and leeches. Their blood circulates in vessels and they have a firm sac of fluid (the coelom) running the length of their body, which keeps motion of the gut separate from motion of the body wall. The coelum is split into sections, with each one corresponding to a body segment. Each body segment contains a set of muscles, and coordination of these muscle sets can send a wave of contraction down the length of the body, or make it flex to and fro. This makes many annelids highly mobile both on land and in the water.

Marine segmented worms—the predatory ragworms and their filter-feeding relatives—carry bundles of bristles along their body, typically borne on little paddles that help with swimming, burrowing, or even walking. This group of bristled, segmented worms are called polychaetes or bristle worms.

Land-living earthworms are more sparsely bristled detritus-feeders, and are important recyclers of dead vegetation and aerators of soil. Many leeches are specialized further, and carry suckers to extract blood from a host. Their saliva contains chemicals that stop blood clotting. Other leeches are predatory. Both earthworms and leeches have a saddle-shaped, glandular structure around their bodies called a clitellum, which they use to make their egg cocoons.

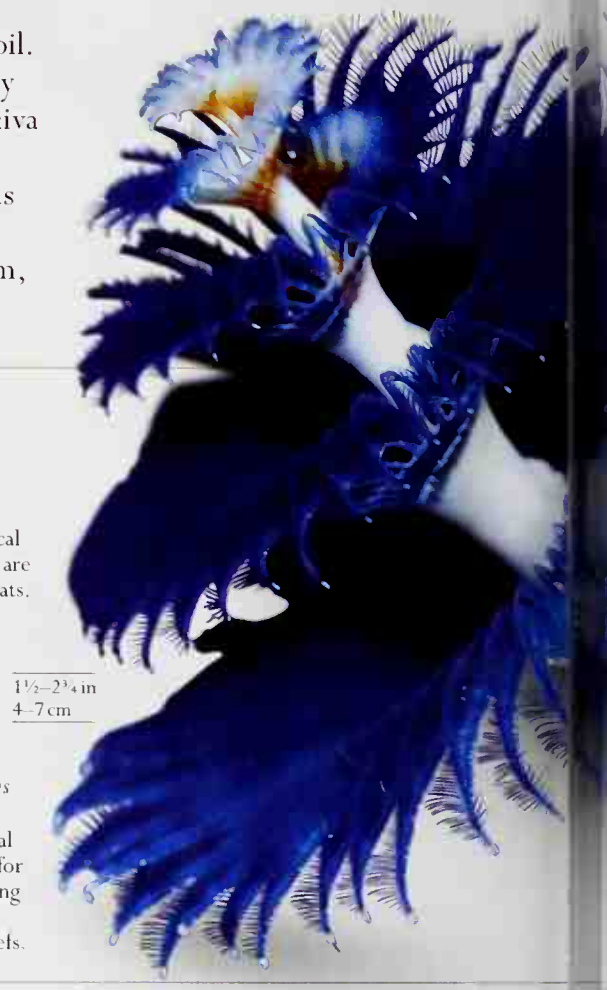
PHYLUM	ANNELIDA
CLASSES	4
ORDERS	8
FAMILIES	About 130
SPECIES	About 15,000

SLUDGE WORM
Tubifex sp.
F: Naididae
This widely distributed worm can be seen in mud polluted by sewage, the front end buried, the rear end wiggling to extract oxygen.

MEGADRILE EARTHWORM
Glossoscolex sp.
F: Glossoscolecidae
Glossoscolex are large earthworms from tropical C. and S. America. Many are found in rain forest habitats.

TIGER WORM
Eisenia foetida
F: Lumbricidae
This European inhabitant of rotting vegetation secretes defensive pungent fluid and, like other earthworms, has a "saddle" for producing cocoons of eggs.

COMMON EARTHWORM
Lumbricus terrestris
F: Lumbricidae
This earthworm—native to Europe but introduced elsewhere—drags leaves into its burrow at night as a source of food.



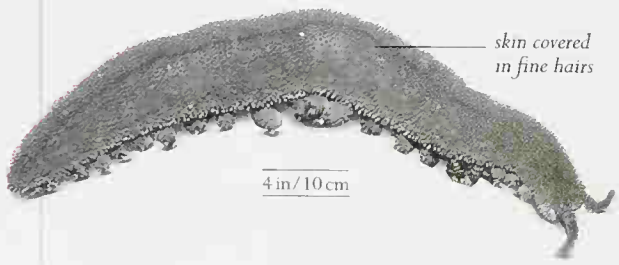
CHRISTMAS TREE TUBE WORM
Spirobranchus giganteus
F: Serpulidae
Characterized by its spiral whorls of tentacles, used for filter feeding and extracting oxygen, this species is widespread on tropical reefs.

VELVET WORMS

These soft-bodied worms, cousins of arthropods, lumber slowly along dark forest floors like giant caterpillars, but they are extraordinary hunters.

These animals have the body of an earthworm and the multiple limbs of a millipede, but belong in a phylum of their own: Onychophora. Velvet worms are rarely seen in their warm native rain forests of tropical America, Africa, and Australasia; they shun the open, preferring to hide in crevices and leaf litter. They come out at night or after rainfall to hunt other invertebrates. Velvet worms capture their prey in a unique way: they immobilize their victims by spraying them with sticky slime that is produced by glands that open through pores straddling the mouth.

PHYLUM	ONYCHOPHORA
CLASS	1
ORDER	1
FAMILIES	2
SPECIES	About 200



SOUTHERN AERICAN VELVET WORM
Peripatopsis moseleyi
F: Peripatopsidae
This species belongs to a family with a globally southern distribution.

CARIBBEAN VELVET WORM
Epiperipatus broadwayi
F: Peripatidae
This species is one of a family of equatorial velvet worms, which typically have more legs than those of the southern continents.

2¾–12 in
6–30 cm

FIREWORM
Hermodice carunculata
F: Amphinomidae

A tropical Atlantic offshore species, this polychaete preys on corals, sucking out the soft flesh from the hard skeleton. Its body extensions have painfully irritating bristles.

4–8 in
10–20 cm

SEA MOUSE
Aphrodita aculeata
F: Aphroditidae

This mud-burrowing scale worm is found in the shallow waters of North Europe. Its scales are covered with a hairy coat.

1–1¾ in 2.5–3 cm

SEA CUCUMBER SCALE WORM
Gastrolepidia clavigera
F: Polynoidea

This Indo-Pacific polychaete has flattened back scales. It is parasitic on sea cucumbers.

2–6 in
5–15 cm

GREEN PADDLEWORM
Eulalia viridis
F: Phyllodocidae

Paddleworms are active carnivores with leaf-shaped flaps on their body extensions. This European species lives among intertidal rocks and kelp.

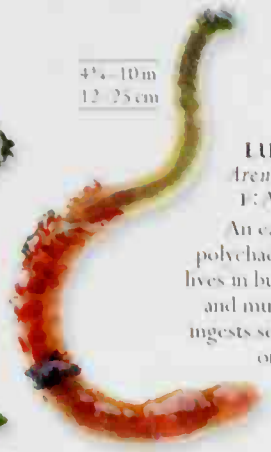
10–16 in 25–40 cm

KING RAGWORM
Alitta virens
F: Nereididae

Ragworms, close relatives of paddleworms, have two-pronged body extensions. This Atlantic mud-burrowing species can deliver a painful bite.

GIANT TUBEWORM
Riftia pachyptila
F: Siboglinidae

This tubeworm lives in the hot sulfur-rich darkness of ocean-floor volcanic vents in the Pacific. The red plume harbors bacteria that make its food using chemicals from these vents.



4¾–10 in
12–25 cm

LUGWORM
Arenicola marina
F: Arenicolidae

An earthwormlike polychaete, the lugworm lives in burrows on beaches and mud flats, where it ingests sediment and feeds on detritus.

3½–13 ft
1–4 m

HONEYCOMB WORM
Sabellaria alveolata
F: Sabellariidae

This tubeworm builds its tubes from sand and shell fragments. Dense populations form honeycomb-like reefs in the Atlantic and Mediterranean.

3½–4 in
8–10 cm

PACIFIC FEATHERDUSTER WORM
Sabellastarte sanctijosephi
F: Sabellidae

A tropical Indo-Pacific tubeworm, this species is common along coastlines, including coral reefs and tidal pools.

2–2¾ in
5–7 cm

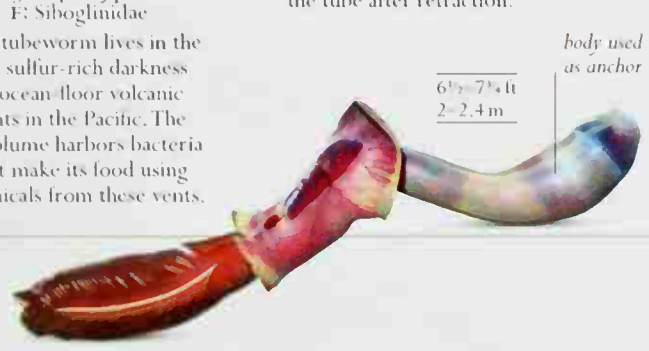
RED TUBE WORM
Serpula vermicularis
F: Serpulidae

Serpulid tubeworms build hard chalky tubes. Like most serpulids, this widespread species has tentacles modified to plug the tube after retraction.

5/16–⅛ in
2–3 mm

NORTHERN SPIRAL TUBEWORM
Spirorbis borealis
F: Serpulidae

The small coiled tube of this tubeworm is cemented to brown *Fucus* seaweeds and kelps along North Atlantic coastlines.



6½–7¾ ft
2–2.4 m

WATER BEARS

Visible only through a microscope, stubby-legged, agile water bears share their aquatic community with microbes and far simpler invertebrates.

Tiny water bears, or tardigrades (meaning "slow-stepped") clamber through miniature forests of water weed, four pairs of short legs clinging on with clawed feet. Most are less than a millimeter long. They abound among moss or algae, where many use their needlelike jaws to pierce the cells of this vegetation and suck its sap. Many water bear species are known only as females, which reproduce asexually by spawning offspring from unfertilized eggs. If its habitat dries up, a water bear is able to survive by going into a kind of suspended animation called cryptobiosis, shrivelling into a husk, sometimes for years at a time, until rainfall revives it.

PHYLUM	TARDIGRADA
CLASSES	3
ORDERS	5
FAMILIES	20
SPECIES	About 1,000

0.25mm

MOSS WATER BEAR
Echiniscus sp.
F: Echiniscidae

Many water bears live in moss, but their ability to survive in a dried state has helped a number of species to disperse worldwide.

0.25mm

SEAWEED WATER BEAR
Echiniscoides sigismundi
F: Echiniscoididae

One of many little-known marine water bears, this species has been recorded among seaweed in coastal locations around the world.

ARTHROPODS

Jointed legs and flexible armor have helped a phylum that includes winged insects and underwater crustaceans to evolve unrivaled diversity.

There are more species of arthropods known to scientists than all the other animal phyla added together—and doubtless many more await discovery. They have an extraordinary range of lifestyles including grazing, predation, filtering particles of food in water, and drinking fluids such as nectar or blood.

Arthropods are coated by an exoskeleton made of a tough material called chitin. It is sufficiently flexible around the joints to allow for mobility, but resists stretching. As arthropods grow, they must periodically molt their exoskeleton, which is replaced by a slightly larger one. The exoskeleton serves as protective armor but also helps reduce water loss in very dry habitats.

BODY PARTS

Arthropods evolved from a segmented ancestor, perhaps like an annelid worm. Body segmentation persists in all arthropods, but is especially obvious in millipedes and centipedes. In other groups, various segments have fused together into discrete body sections. Insects are divided into a sensory head, a muscular thorax with legs and wings, and an abdomen containing most of the internal organs. In arachnids and some crustaceans, the head and thorax are fused into one single section.

GETTING OXYGEN

Aquatic arthropods, such as crustaceans, breathe with gills. The bodies of most land arthropods—insects and myriapods—are permeated by a network of microscopic, air-filled tubes called tracheae. These open out through pores known as spiracles on the sides of the body, usually one pair per body section. Small muscles inside the spiracles regulate the flow of air by means of valves. In this way, oxygen can seep directly to all cells of the body and does not need to be transported in blood. Some arachnids breathe with tracheae; others with leafy chambers in their abdomen that evolved from the gills of their aquatic ancestors. Most use a combination of the two.

PHYLUM	ARTHROPODA
CLASSES	14
ORDERS	69
FAMILIES	About 2,650
SPECIES	About 1,230,000

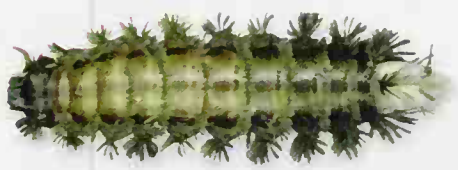
DEBATE

CAMOUFLAGE OR MIMICRY

Many arthropods have adapted to their environment by blending imperceptibly into it. Stick insects, for example, look so like twigs that they are very difficult for predators to spot. In contrast, arthropods, such as wasps, have evolved bright colors that warn others they are distasteful or dangerous. The hornet moth is completely harmless but avoids predation because it looks and sounds exactly like a hornet. Despite their similar appearance, other anatomical features separate them into different families. The hornet moth belongs to the family Lepidoptera and the hornet to the family Hymenoptera.

MILLIPEDES AND CENTIPEDES

Millipedes and centipedes form a group of multi-segmented arthropods called myriapods. Millipedes typically have two legs per body segment; centipedes have only one per segment. Whereas millipedes are vegetarian, centipedes are predatory carnivores.



2–3 mm/1/16–1/8 in

BRISTLY MILLIPEDE
Polyxenus lagurus
F: Polyxenidae

One of a family of millipedes armed with defensive bristles, this tiny species of the Northern Hemisphere lives under the bark of trees and in leaf litter.

AMERICAN SHORT-HEADED MILLIPEDE
Brachycybe sp.
F: Andrognathidae

This is a North American representative of a family of small, flat millipedes that live in rotting wood and leaf litter.

3/8–3/4 in
1–2 cm

BROWN GIANT PILL MILLIPEDE
Zephronia sp.
F: Sphaerotheriidae

Giant pill millipedes, such as this Bornean species, differ from their smaller northern hemisphere relatives in that they have 13 body sections rather than 12.

1 1/4–1 1/2 in
3–4 cm

BLACK GIANT PILL MILLIPEDE
Zoosphaerium sp.
F: Sphaerotheriidae

One of many southern hemisphere giant pill millipedes, this species is native to Madagascar.

WHITE-RIMMED PILL MILLIPEDE
Glomeris marginata
F: Glomeridae

Pill millipedes, such as this European species, have fewer body segments than other millipedes and can roll into a ball when disturbed.

BLACK SNAKE MILLIPEDE
Ischyopsalulus niger
F: Julidae

Unlike its close relatives, this distinctive, white-legged millipede from western Europe spends much time above ground—even climbing trees and walls.

¾–1¼ in
1.5–4 cm

¾–1¼ in
1.5–3 cm

BROWN SNAKE MILLIPEDE
Julus scandinavius
F: Julidae

A member of a large family of cylindrical millipedes with ring-encased segments, this species occurs in European deciduous woodland, especially on acid soils.

8–11 in / 20–28 cm

AFRICAN GIANT MILLIPEDE
Archispirostreptus gigas
F: Spirostreptidae

One of the largest of all millipedes, this species occurs in tropical Africa and is one of many species that release irritating chemicals to defend themselves.

3–5 in
7.5–13 cm

AMERICAN GIANT MILLIPEDE
Narceus americanus
F: Spirobolidae

This large, Atlantic coast millipede belongs to a family of mainly American, cylindrical millipedes. Like its relatives, it releases noxious chemicals in defense.

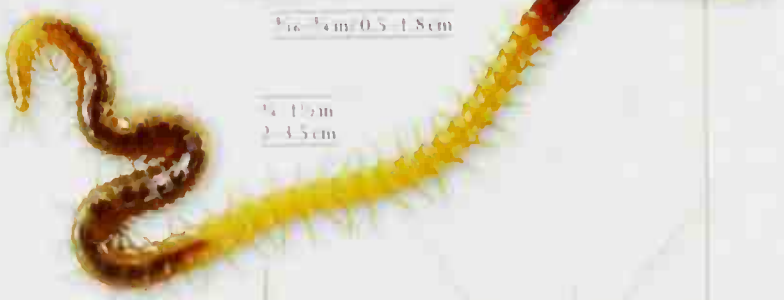
BORING MILLIPEDE
Polyzonium germanicum
F: Polyzoniidae

This somewhat primitive millipede has a scattered distribution in Europe. It lives in woodland and resembles beech bud scales when coiled.

¾–1¼ in
1.5–3 cm

EASTERN FLAT-BACKED MILLIPEDE
Polydesmus complanatus
F: Polydesmidae

Polydesmids have projections on their exoskeleton that make them look flat-backed. This eastern European species is a fast runner.



¾–1½ in
2–3.5 cm

YELLOW EARTH CENTIPEDE
Geophilus flavus
F: Geophilidae

Eyeless geophilids have more segments (and therefore legs) than other centipedes. This European soil-dweller has been introduced to the Americas and Australia.

1¼–2¼ in
4–6 cm

TANZANIAN FLAT-BACKED MILLIPEDE
Ceremus diapherus
F: Oxydesmidae

The shiny pitted surface typical of many of the eyeless flat-backed millipedes is especially prominent in this species from the tropics.

¾–1¼ in
2–3 cm

1–2 in
2.5–5 cm

BANDED STONE CENTIPEDE
Lithobius variegatus
F: Lithobiidae

Once thought to be confined to Britain, this centipede is now known in continental Europe, where native populations have unbanded legs.

¾–1¼ in / 2–3 cm

BROWN STONE CENTIPEDE
Lithobius forficatus
F: Lithobiidae

Found sheltering beneath bark and rock, stone centipedes characteristically have 15 body segments. This globally widespread species frequents forest, garden, and seashore.

poison fang

8–10 in
20–25 cm

TIGER GIANT CENTIPEDE
Scolopendra hardwickei
F: Scolopendridae

Many of the giant *Scolopendra* centipedes have vibrant warning colors. This Indian species is one of several with a tiger pattern.

one pair of jointed legs per body segment

4–6 in
10–15 cm

BLUE-LEGGED CENTIPEDE
Ethmostigmus trigonopodus
F: Scolopendridae

This close relative of the giant *Scolopendra* centipedes is widespread throughout Africa and is one of several species with blue-tinted legs.

HOUSE CENTIPEDE
Scutigera coleoptrata
F: Scutigeridae

An unmistakable centipede, this long-legged animal with compound eyes is one of the fastest invertebrate runners. Native to the Mediterranean region, it has been introduced elsewhere.

ARACHNIDS

A class within the phylum arthropoda, arachnids include predatory spiders and scorpions, as well as mites and blood-sucking ticks.

Arachnids and related horseshoe crabs are chelicerates—arthropods named for their clawlike mouthparts (chelicerae). The head and thorax of chelicerates are fused into one body section, which carries the sensory organs, brain, and four pairs of walking legs. Unlike other arthropods, chelicerates lack antennae.

EFFECTIVE PREDATORS

Scorpions, spiders, and their relatives are land-living predators that have evolved quick ways of immobilizing and killing prey. Spiders use their chelicerae as fangs to inject venom and many first ensnare prey by spinning webs. Scorpions poison their prey with the sting in their tail. Between their legs and chelicerae, arachnids also have a pair of limblike pedipalps. These are modified into grasping pincers in scorpions or sperm-transferring clubs in male spiders.

MICROSCOPIC DIVERSITY

Many mites are too small to see with the naked eye. They abound in almost every habitat, where they scavenge on detritus, prey on other tiny invertebrates, or live as parasites. Some lead innocuous lives in skin follicles, feathers, or fur; others cause disease or allergy. One group—the ticks—are blood-suckers and can spread disease-causing microbes.

PHYLUM	ARTHROPODA
CLASS	ARACHNIDA
ORDERS	13
FAMILIES	650
SPECIES	65,000

This female wasp spider waits at the center of her dewy orb web to ensnare any insect prey that might fly in.

4 in / 10 cm

CHILEAN BURROWING SCORPION
Centromachetes pococki
F: Bothriuridae

A burrowing scorpion from the Southern Hemisphere, this species occurs in temperate forests in South America, often under rotting logs.

⅛ in / 3 mm

MARITIME PSEUDOSCORPION
Neobisium maritimum
F: Neobisiidae

A common European coastal pseudoscorpion, this species lives under stones and seaweed in the splash and upper intertidal zones.

⅛ in / 3 mm

FINGER-CLAWED PSEUDOSCORPION
Dactylochelifer latreillei
F: Cheliferidae

Pseudoscorpions are tiny arachnids that kill their prey with venomous pincers. This European species lives at the base of seashore grasses.

1/16 in / 2 mm

BROAD-HEADED PSEUDOSCORPION
Chthonius ischnocheles
F: Chthoniidae

Pseudoscorpions, such as this European species, sometimes find small prey in animal nests by hitchhiking in the fur or feathers of the parent animal.

6–10 in
15–25 cm

IMPERIAL SCORPION
Pandinus imperator
F: Scorpionidae

One of the largest of all scorpions, this African forest species is more docile and has a milder sting than many of the desert-dwellers.

4–7 in
10–18 cm

AFRICAN ROCK SCORPION
Hadogenes phyllodes
F: Liochelidae

Typical of a family of rock scorpions, this southern African species has a broad, flat body for squeezing into cracks between rocks.

2¾–4 in
7–10 cm

COMMON EUROPEAN SCORPION
Buthus occitanus
F: Buthidae

Found throughout North Africa and around the Mediterranean, the venom of this species is less potent than that of its southern relatives.

YELLOW THICK-TAIL SCORPION
Androctonus amoreuxi
F: Buthidae

Most thick-tail scorpions are small but have potent venoms. This large species from the Sahara and Middle East has caused human fatalities.

⅜ in
1 cm

SAY'S HARVESTMAN
Vonones sayi
F: Cosmetidae

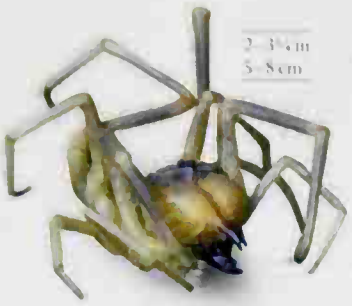
Harvestmen have undivided bodies and are nonvenomous. Many, including this American species, produce distasteful chemicals to deter predators.

AMERICAN SUN SPIDER
Eremobates sp.
F: Eremobatidae

Eremobates are sun spiders with particularly large jaws. This nocturnal species is found in warm parts of North and Central America.

PAINTED SUN SPIDER
Metasolpuga picta
F: Solpugidae

Sun spiders, also called camel spiders, are fast-running, desert-living relatives of true spiders. This is a diurnal species from Africa.



WIND SPIDER
Galeodes arabs
F: Galeodidae

A common species in the largest genus of sun spiders, this Middle Eastern species is named for its ability to tolerate sand storms.

FLOUR MITE
Acarus siro
F: Acaridae

This is an important pest that feeds on stored cereal products. Like many other species, its presence can cause allergic reactions in humans.

CHIGGER MITE
Neotrombicula autumnalis
F: Trombiculidae

Adults of chigger mites are vegetarian, but their larvae feed on the skin of other animals, including humans. Their chewing causes intense irritation.

COMMON VELVET MITE
Trombidium holosericeum
F: Trombidiidae

This is a widespread Eurasian species of velvet mite. When young, it lives parasitically off other arthropods, but becomes predatory when mature.

TWO-SPOT SPIDER MITE
Tetranychus urticae
F: Tetranychidae

Spider mites are a family of mites that suck the sap of plants. They weaken the plant and can transmit viral diseases.

LONE STAR TICK
Amblyomma americanum
F: Ixodidae

Like other blood-sucking ticks, this species—common in woodlands in the USA—can transmit a number of disease-causing microbes.

VARROA MITE
Varroa cerana
F: Varroidae

Parasitic on honeybees, young of this mite feed on bee larvae. When mature, they attach to adult bees and spread to other hives.

MANGE MITE
Sarcoptes scabiei
F: Sarcoptidae

This tiny mite burrows into the skin of various mammal species, completing its life cycle there. It causes scabies in humans and mange in carnivores.

CHICKEN MITE
Dermanyssus gallinae
F: Dermanyssidae

A blood-sucking parasite of poultry, this mite lives—and completes its life cycle—in crevices away from its host, but emerges at night to feed.

PERSIAN FOWL TICK
Argas persicus
F: Argasidae

A blood-sucking parasite of fowl, including domestic chickens, this oval-shaped, soft-bodied tick can spread disease between birds and can cause paralysis.

SPINY HARVESTMAN
Discocyrtus sp.
F: Gonyleptidae

This South American harvestman has spiny hind legs as a possible defense against predators. It lives under stones and logs in forests.

HORNED HARVESTMAN
Phalangium opilio
F: Phalangiidae

A common harvestman of Eurasia and North America, the male of this species has a jaw ornament with projecting horns.

WHIP SPIDER
Phrynus sp.
F: Phrynidae

Whip spiders are not true spiders. They have long, whiplike front legs and pincers for grabbing prey, but lack venom. All are tropical.

WHIP SCORPION
Thelyphonus sp.
F: Thelyphonidae

Tropical whip scorpions such as this species have a whiplike tail, but no sting or venom. However, they can spray acidic fluid from their abdomens.

»

¼–2¾ in
2–7 cm

FUNNEL-WEB SPIDER
Atrax robustus
F: Hexathelidae

Females of this aggressive Australian spider live in burrows with funnel-like, silk-lined entrances. The dangerous bite most frequently comes from males wandering for mates.

2–3 in
5–7.5 cm

MEXICAN RED-KNEED TARANTULA
Brachypelma smithi
F: Theraphosidae

This is one of many theraphosids: large-bodied spiders popularly called bird-eaters or tarantulas. They prey on large insects, rarely on small vertebrates.

2–3 in
5–7.5 cm

CHACO TARANTULA
Acanthoscurria insubtilis
F: Theraphosidae

Many large theraphosids, such as this South American species, live in disused rodent burrows. Despite their popular name, they do not eat birds.

4¾–5½ in
12–14 cm

GOLIATH TARANTULA
Theraphosa blondi
F: Theraphosidae
O: Araneae

Like many of its relatives, this South American bird-eater—the largest of all spiders—discharges irritating hairs when threatened.

1–2 cm
⅜–¾ in

NORTH AMERICAN TRAPDOOR SPIDER
Ummidia audouini
F: Ctenizidae

This N. American spider builds a cork-like trapdoor set with trip-lines. Stumbling prey alert the predator waiting in a silk-lined burrow beneath.

2 mm
1/16 in

SIX-EYED SPIDER
Oonops domesticus
F: Oonopidae

This tiny, pink, six-eyed spider occurs in warm parts of Eurasia, but further north—including in Britain—it is found only in houses.

⅜–½ in
1–1.2 cm

WOODLOUSE SPIDER
Dysdera crocata
F: Dysderidae

This nocturnal European spider has huge fangs that catch and break into the hard exoskeletons of woodlice. It occurs in damp places where woodlice are abundant.

¼–½ in
0.6–1.6 cm

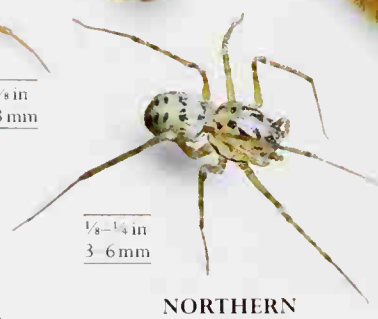
LADYBIRD SPIDER
Eresus kollari
F: Eresidae

Only males of this Eurasian spider have the eponymous ladybird pattern. It catches prey from within silk-lined burrows on heathland slopes.

⅛ in
3 mm

DWARF SPIDER
Gonatium sp.
F: Linyphiidae

Typical of a very large family of tiny "money spiders," this Northern Hemisphere species builds sheet webs and can travel on the wind by ballooning on silken threads.



⅛–¼ in
3–6 mm

NORTHERN SPITTING SPIDER
Scytodes thoracica
F: Scytodidae

Spitting spiders are sluggish spiders that spray gummy, poisonous fluid to immobilize prey before biting. Its range spans the Northern Hemisphere.

5/32–½ in
4–13 mm

EUROPEAN GARDEN SPIDER
Araneus diadematus
F: Araneidae

A weaver of orb webs from the Northern Hemisphere, this spider of woodland, heath, and gardens is marked by a white cross on a variable background color.

7/32–⅜ in
7–10 mm

DADDY LONG-LEGS SPIDER
Pholcus phalangioides
F: Pholcidae

Spindly-legged pholcids vibrate their webs when disturbed. Many are cave dwellers, but this cosmopolitan species inhabits houses. Females carry eggs in their jaws.

⅜ in
1.2 cm

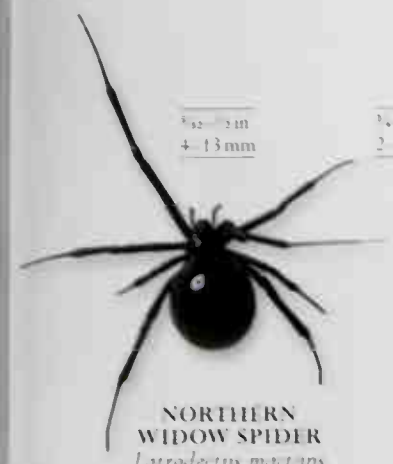
CAVE SPIDER
Meta menardi
F: Araneidae

Many spiders of the genus *Meta*, such as this European species, inhabit caves, where they suspend their drop-shaped egg sacs.

1/16–11/32 in
2–9 mm

CRAB-LIKE SPINY ORB-WEAVER
Gasteracantha cancriformis
F: Araneidae

One of many American orb-weavers with defensive spines, this species inhabits the southern USA and the Caribbean. Colors of the body and spines vary.



1/32–1/2 in
4–13 mm

NORTHERN WIDOW SPIDER
Latrodectus mactans
F: Theridiidae

A small spider with venom unusually dangerous to humans, females of this North American species frequently eat the smaller male after mating.

1/4–1 in
2–2.7 cm

TARANTULA WOLF SPIDER
Lycosa tarantula
F: Lycosidae

This species is the only true tarantula, a large member of the wolf spider family from Mediterranean Europe, not to be confused with hairy-bodied bird-eaters.

1/4–3/8 in
5–8 mm

EUROPEAN WOLF SPIDER
Pardosa amentata
F: Lycosidae

A typical wolf spider, this furry brown spider hunts over ground without a web. Females carry egg sacs and young ride on the mother's back.

NURSERY WEB SPIDER
Pisaura mirabilis
F: Pisauridae

Females of this Eurasian spider carry their egg sac beneath the body by their jaws, before weaving a nursery "tent" of silk to protect hatching young.

3/8–1/2 in
1–1.5 cm

1/4–1/2 in
0.6–4.5 cm

AMERICAN GOLDEN SILK ORB-WEAVER
Nephila clavipes
F: Nephilidae

This is the only American species of a group of tropical golden orb-weavers. It is distinguished by feathery tufts on its legs.

1/4–3/4 in
1–2.3 cm

RAFT SPIDER
Dolomedes fimbriatus
F: Dolomedidae

A European swamp spider, this species preys on small fish, which it can attract by vibrating the water surface with its legs.

1/4–3/4 in
0.8–2 cm

WATER SPIDER
Argyroneta aquatica
F: Cybaeidae

The only routinely aquatic spider, this Eurasian pond species builds a submerged, air-filled chamber, inside which it eats its prey, including small fish.

1/4–3/4 in
1–1.8 cm

GIANT HOUSE SPIDER
Tegenaria duellica
F: Agelenidae

A member of a group of spiders that build sheet webs with tubular retreats, this species frequents buildings across the Northern Hemisphere.

1/4–1/2 in
2–4.5 cm

BRAZILIAN WANDERING SPIDER
Phoneutria nigriventer
F: Ctenidae

Wandering spiders get their name from their nocturnal roaming habits. This species from Brazilian forests can deliver a dangerous bite.

1/4–1/2 in
6–10 mm

GRASS CRAB SPIDER
Tibellus oblongus
F: Philodromidae

An elongated crab spider, this species ranges across the Northern Hemisphere and ambushes prey from a position stretched along a grass blade.

1/8–1/2 in
3–11 mm

GOLDENROD CRAB SPIDER
Misumena vatia
F: Thomisidae

Females of this Northern Hemisphere spider can change their color from white to yellow for camouflage in flowers before ambushing nectar-feeding insects.

1/8–1/4 in
2.2–2.8 mm

DOMESTIC HUNTSMAN SPIDER
Heteropoda venatoria
F: Sparassidae

Widespread throughout tropical and subtropical regions, this large but harmless spider is sometimes welcomed in homes for preying on cockroaches.

1/8–3/8 in
3–9 mm

ELEGANT JUMPING SPIDER
Chrysilla lauta
F: Salticidae

Jumping spiders are especially diverse in the tropics. Many, such as this East Asian species, are strikingly colored, sometimes to aid communication.

1/4–7/32 in
5–7 mm

BROWN JUMPING SPIDER
Evarcha arcuata
F: Salticidae

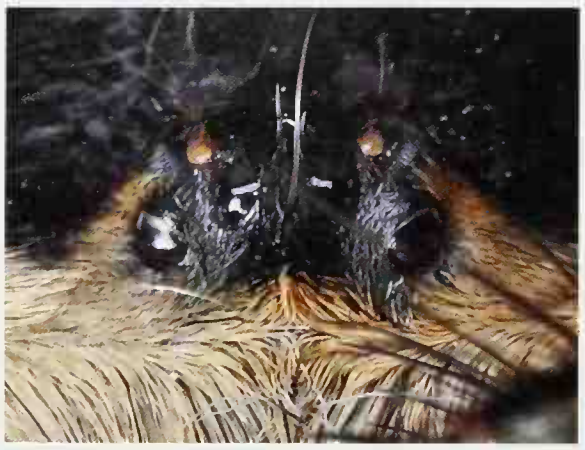
This Eurasian grassland species is one of thousands of species of jumping spiders with acute binocular vision and complex courtship behavior.

MEXICAN RED-KNEED TARANTULA

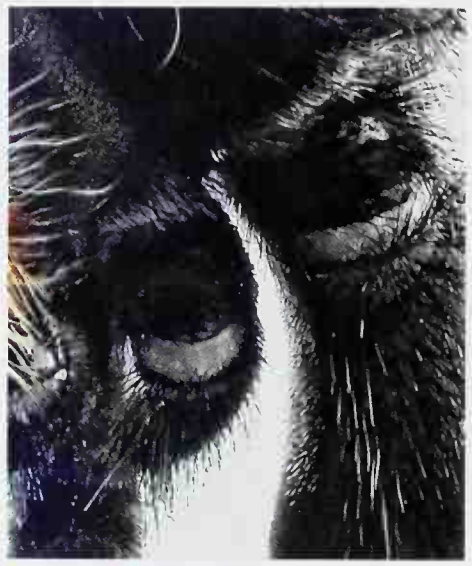
Brachypelma smithi

SIZE Body length 2–3 in (5–7.5 cm)
HABITAT Tropical deciduous forests
DISTRIBUTION Mexico
DIET Mostly insects

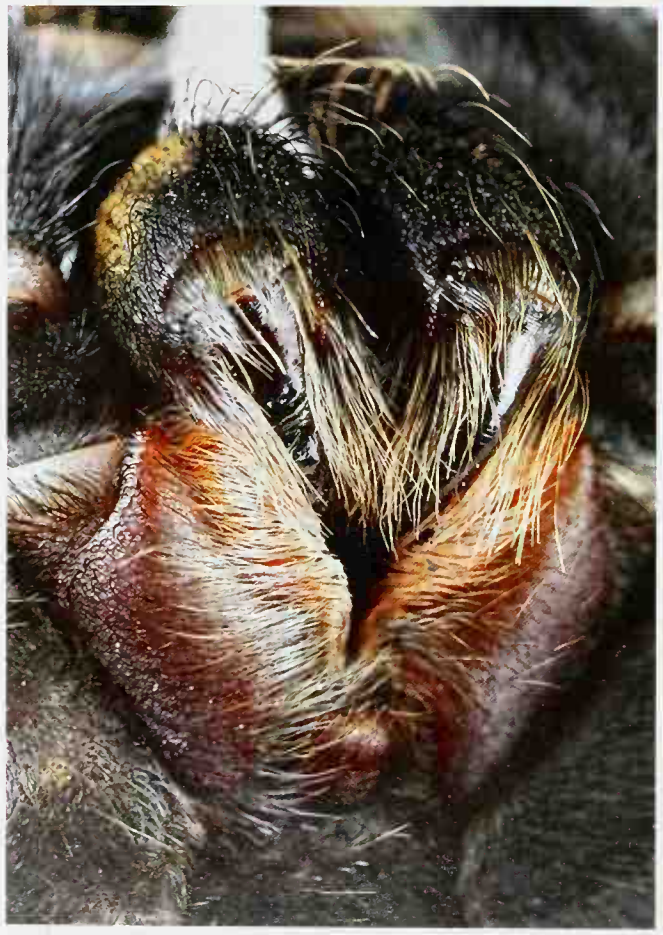
With its stout, furry body, the Mexican red-kneed tarantula might seem more mammal-like than spiderlike. The female can live up to 30 years, which is unusual for an invertebrate, but the life span of the male is only up to six years. *Brachypelma smithi* is one of a group of spiders that gets the nickname of bird-eater because of size, and although most of their diet consists of fellow arthropods, they can and do take down small mammals and reptiles when the opportunity arises. In its native Mexico this species lives in burrows in earth banks, where it is safe to molt and lay eggs, and from which it ambushes its prey. Habitat destruction is now a threat, and, because the species makes a popular pet, it is routinely bred in captivity.



< EYES
Like most spiders, the tarantula has eight simple eyes arranged at the front of the head. Even so, it has poor vision, and relies more on touch than sight to sense its surroundings and the presence of prey.

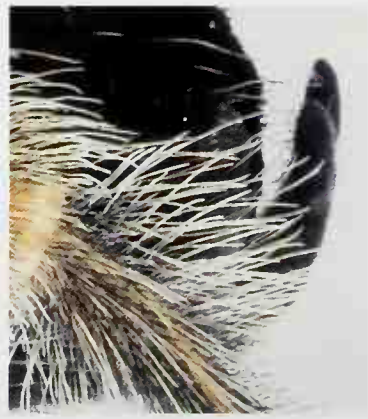


< JOINTS
Like all arthropods, tarantulas have jointed legs. Each leg consists of seven tubular sections of exoskeleton that connect via flexible joints. Muscles run through these joints to move the sections.



^ VENOMOUS FANGS
Tarantula fangs hinge forward when attacking prey unlike most other spiders, whose fangs are angled toward each other. Both fangs inject venom from muscular sacs within the head to paralyze the victim.

< FOOT
At the tip of each foot are two claws used for grip as the tarantula moves. As in other hunting spiders, there are also pads of tiny hairs for extra purchase on smooth surfaces.



< SPINNERETS
Glands in the abdomen produce silk in liquid form. Using its hind legs, the tarantula pulls the silk from tubes called spinnerets. The silk solidifies into threads used to make egg sacs and line the spider's burrow.

dark abdomen contains most of the animal's vital internal organs

orange-red patella, or knee

pulps are used for feeling, gripping prey, and transferring sperm to the female

UNDERSIDE >
The head and thorax are fused into one body part, which carries the legs and mouthparts. The abdomen has openings for breathing and reproduction, and two pairs of spinnerets at the rear.

^ HAIRY WEAPONS
Like many tropical American tarantulas, this spider defends itself by rubbing its hind legs against its abdomen to release the barbed, stinging hairs that grow there. These urticating hairs are tiny and light, and designed to float in a cloud around a predator's face, getting in its eyes, nose, and mouth. They cause intense irritation when lodged in skin.

SEA SPIDERS

These fragile-looking marine animals live among seaweeds in shallow seas and coral reefs in tropical waters. The largest species live in the deep ocean.

Sea spiders of the class Pycnogonida are not true spiders, and are so remarkably different from other arthropods that some scientists think they belong to an ancient lineage that is not closely related to any groups alive today. Others think they are distant cousins of the arachnids. Most sea spiders are small—less than ⅜ inch (1 cm) in body length. They have three or four pairs of legs and the head and thorax are fused together. Instead of clawlike mouthparts they have a stabbing proboscis, which they use like a hypodermic needle to suck fluids from their invertebrate prey. Their spindly body shape means they do not need gills; they rely instead on oxygen seeping directly into all their cells through their body surface.

PHYLUM	ARTHROPODA
CLASS	PYCNOGONIDA
ORDER	1
FAMILIES	8
SPECIES	About 1,000

¾ in/2 cm

GIANT SEA SPIDER
Colossendeis megalonyx
F: Colossendeidae
One of the largest of all sea spiders, this is a deep-sea animal of sub-Antarctic waters, with a leg span of 28 in (70 cm).

5/16 in/8 mm

SPINY SEA SPIDER
Endeis spinosa
F: Endeidae
This sea spider—found around European coasts but possibly ranging elsewhere—has an especially spindly body, with a long cylindrical proboscis.

3/16 in/5 mm

FAT SEA SPIDER
Pycnogonum littorale
F: Pycnogonidae
Unlike most other sea spiders, this European species has a thick body and comparatively short, curved, clawed legs. It feeds on anemones.

YELLOW-KNEED SEA SPIDER
Unknown sp.
F: Callipallenidae
Some species of sea spiders—such as this species of Australian reefs—are strikingly colored, often as camouflage against their colorful surroundings.

5/16 in/8 mm

GRACEFUL SEA SPIDER
Nymphon gracile
F: Nymphonidae
One of the most common sea spiders of the Northeast Atlantic, this species occurs in the intertidal zone and in offshore shallows.

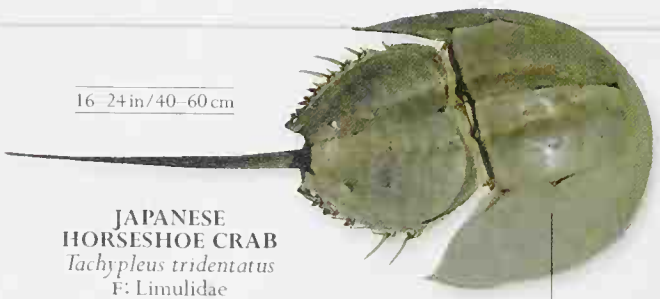
HORSESHOE CRABS

The Merostomata are a small class of sea-dwelling relatives of spiders and scorpions. Of prehistoric origin, they are widely regarded as "living fossils."

Horseshoe crabs were far more diverse in prehistory, when animals like them may well have been the first chelicerates on Earth. Their clawlike mouthparts and lack of antennae indicate that, despite their hard carapace, horseshoe crabs are most closely related to arachnids. The leaflike gills on the underside of their abdomens are the forerunners of similar internal structures—the so-called book lungs—that arachnids use to breathe on land. The pedipalps are used as a fifth pair of legs, which is one pair more than in spiders. Horseshoe crabs grub around in muddy ocean waters to catch their prey. They come ashore in large numbers to breed, laying their spawn in sand.

PHYLUM	ARTHROPODA
CLASS	MEROSTOMATA
ORDER	1
FAMILY	1
SPECIES	4

16–24 in/40–60 cm



JAPANESE HORSESHOE CRAB
Tachypleus tridentatus
F: Limulidae
This horseshoe crab spawns in sandy shores of Eastern Asia. Habitat destruction and pollution have depleted its numbers in some parts of its range.

fused head and thorax covered by carapace

long spinelike tail

spiny abdomen

ATLANTIC HORSESHOE CRAB
Limulus polyphemus
F: Limulidae
This species of the Northwest Atlantic Ocean gathers in spring, breeding in swarms along American coastlines—especially around the Gulf of Mexico.

16–24 in
40–60 cm

CRUSTACEANS

Most crustaceans are aquatic, breathe with gills, and have limbs for crawling or swimming. A few are sedentary as adults, parasitic, or land living.

The basic body plan of a crustacean consists of a head, a thorax, and an abdomen, although in many groups the head and thorax are fused together. In crabs, lobsters, and shrimps a frontal flap grows backward to cover the entire head and thorax with a shelllike carapace. Crustaceans are the only arthropods that have two pairs of antennae and primitively two-pronged limbs. Limbs on the thorax are usually used for locomotion, but in some species they are modified as pincers for feeding or defense. Many crustaceans also have well-developed abdominal limbs, which are often used for brooding young. Gills tie most crustaceans to water, although woodlice and some crabs have modified breathing organs that enable them to live in damp places on land.

Being permanently underwater, where their weight is supported, allows crustaceans to develop thick, heavy exoskeletons. Many species have exoskeletons that are hardened with minerals, which are reabsorbed between molts when the outer coating of the body is shed. With their bodies buoyed up by water, many crustaceans have become bigger than their land-based relatives. The world's largest arthropod is the deep-sea Japanese spider crab (leg span 13ft/4m). At the other extreme, crustaceans make up the bulk of animal life in plankton, either as tiny larvae or as an adult shrimp and krill.

PHYLUM	ARTHROPODA
SUBPHYLUM	CRUSTACEA
ORDERS	42
FAMILIES	About 830
SPECIES	About 50,000

DEBATE

CRUSTACEAN ANCESTRY

Crustaceans have many unique features, including double antennae and two-pronged limbs, that suggest they are exclusive descendants of a single common ancestor. However, recent DNA analysis suggests that insects are also descended from the crustacean group.

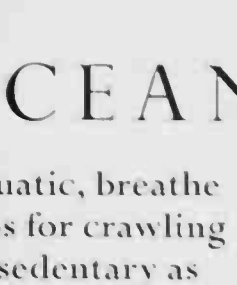
WATER FLEAS AND RELATIVES

The class Branchiopoda are primarily freshwater crustaceans, which make up part of the plankton that flourish in short-lived pools, surviving long periods of drought as eggs. Their thoraxes carry leafy limbs for breathing and filter feeding. Water fleas are typically encased in a transparent carapace.

¼–½in
1–1.5cm

BRINE SHRIMP
Artemia salina
F: Artemiidae

This soft-bodied, stalk-eyed animal is found worldwide in salt pools and swims upside-down. Its hard-shelled eggs can resist years of drought.



⅛–¼in
2–5mm

LARGE WATER FLEA
Daphnia magna
F: Daphniidae

This North American water flea, like its relatives, can brood eggs inside its carapace. These hatch without fertilization, rapidly populating ponds as a result.

⅛in
1.5mm

MARINE WATER FLEA
Evadne nordmanni
F: Podonidae

Most water fleas—named for their jerky swimming—occur in stagnant freshwater pools. This, however, is a saltwater species of oceanic plankton.

2in
5cm

rear limb

VERNAL POOL TADPOLE SHRIMP
Lepidurus packardi
F: Triopsidae

Tadpole shrimps are ancient, bottom-living crustaceans of temporary freshwater pools. Relatives of this Californian species have changed little in 220 million years of evolution.

BARNACLES AND COPEPODS

Like other marine crustaceans, the class Maxillopoda start life as tiny planktonic larvae. Barnacle larvae cement themselves, head down, on rocks. Most copepods stay free-swimming, although some become parasites.

Vto ⅛in
1–2.5mm

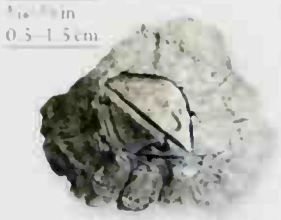
GIANT COPEPOD
Macrocyclops albidus
F: Cyclopidae

Copepods are tiny predators of plankton; this widespread species even preys on mosquito larvae, offering a potential means of controlling these insects.

DEEP SEA GOOSE BARNACLE
Neolepas sp.
F: Scalpellidae

This goose barnacle ally lives around volcanic vents on the ocean floor, where it filter-feeds on other organisms, including bacteria.

2–4in 5–10cm



COMMON ACORN BARNACLE
Semibalanus balanoides
F: Archaeobalanidae

Sensitive to drying out, this intertidal species is most abundant at the base of the barnacle zone on exposed North Atlantic rocky coastlines.

2–4in 5–10cm

GIANT ACORN BARNACLE
Balanus nubilus
F: Balanidae

The world's largest barnacle, this species occurs attached to rocks below the intertidal level along the Pacific North American coast.

3½–36in
8–90cm

COMMON GOOSE BARNACLE
Lepas anatifera
F: Lepadidae

Goose barnacles are attached—mostly to oceanic flotsam—by a flexible stalk. This species occurs in temperate waters of the Northeast Atlantic.

¾in
1.5cm

SEA LOUSE
Caligus sp.
F: Caligidae

A representative of a group of copepods that are parasitic on marine fishes, this crustacean attacks salmon and related species.

¾–1¼in
2–3cm

ASIAN ACORN BARNACLE
Tetraclita squamosa
F: Tetraclitidae

This acorn barnacle lives in the intertidal zone on Indo-Pacific shores. Recent research suggests it actually consists of several similar species.

Vto ¾in
0.5–1cm

COMMON FISH LOUSE
Argulus sp.
F: Argulidae

This is a flattened, fast-swimming crustacean with an oval carapace. It uses suckers to attach to fish and suck their blood.

Vto ¾in
1.5mm

GLACIAL COPEPOD
Calanus glacialis
F: Calanidae

Within Arctic Ocean plankton, this copepod is an important part of the food chain.

SEED SHRIMPS

Seed shrimps belong to the class Ostracoda. The entire body of a seed shrimp is enclosed within a two-valve hinged carapace, with just the limbs poking through. If threatened, the animal can shut itself inside. These small crustaceans crawl through vegetation in marine and freshwater habitats; some use their antennae to swim.

¾–1¼ in
2–3 cm

GIANT SWIMMING SEED SHRIMP
Gigantocypris sp.
F: Cypridinidae

Most seed shrimps are tiny crustaceans with two-valved carapaces; this is a large, deep-sea species with big eyes for hunting bioluminescent prey.

1/64–1/16 in
0.5–2 mm

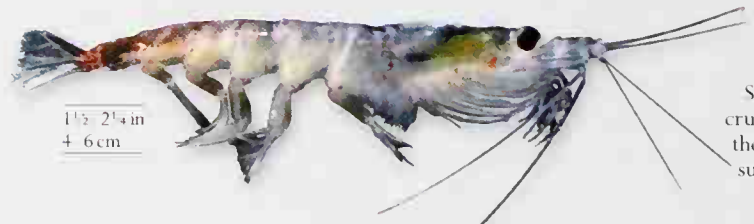
CRAWLING SEED SHRIMP
Cypris sp.
F: Cyprididae

This widespread freshwater crustacean belongs to a group of small, hard-shelled seed shrimps that crawl through detritus.

CRABS AND RELATIVES

The Malacostraca class is the most diverse crustacean group. The basic features are head, thorax, and an abdomen with multiple limbs. Two large orders within this class include the decapods, which have a carapace that curves around the fused head-thorax to contain a gill cavity, and the isopods (woodlice and relatives), which lack a carapace and are the largest group of land-living crustaceans.

1½–2¼ in
4–6 cm



ANTARCTIC KRILL
Euphausia superba
F: Euphausiidae

Swarms of these plankton-feeding crustaceans are critical components of the Southern Ocean food chains that support whales, seals, and seabirds.

RELICT OPOSSUM SHRIMP
Mysis relicta
F: Mysidae

Translucent, feathery-legged opossum shrimps carry their larvae in a brood pouch. Most live in coastal waters, but this species is found in freshwaters in the Northern Hemisphere.

⅜–¾ in
1–1.8 cm

COMMON SANDHOPPER
Orchestia gammarellus
F: Talitridae

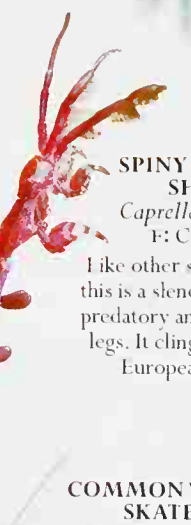
One of many amphipods (sideways-flattened crustaceans), this is a European intertidal sandhopper—so called because it can jump by flipping its abdomen.

½–⅞ in
1.5–2.2 cm

⅜–¾ in
1–2 cm

COMMON FRESHWATER SHRIMP
Gammarus pulex
F: Gammaridae

This northern European amphipod, abundant in freshwater streams, belongs to a family of detritus-eating freshwater shrimps. Related species inhabit brackish waters.



½ in/13 mm

SPINY SKELETON SHRIMP
Caprella acanthifera
F: Caprellidae

Like other skeleton shrimps, this is a slender, slow-moving, predatory amphipod with few legs. It clings to seaweeds in European rockpools.

abdomen

tail fin used for swimming

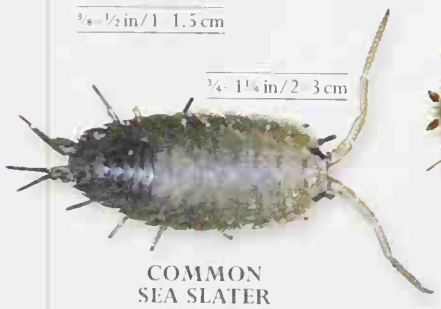
segmented exoskeleton

COMMON WATER SKATER
Asellus aquaticus
F: Asellidae

A common European member of a family of freshwater woodlice relatives, this species crawls among detritus in stagnant water.

⅜–½ in/1–1.5 cm

¾–1¼ in/2–3 cm



COMMON SEA SLATER
Ligia oceanica
F: Ligiidae

A large coastal woodlouse, this European species lives in rock crevices above the intertidal zone. It feeds on detritus.

4–4¾ in
10–12 cm

BLACK-HEADED WOODLOUSE
Porcellio spinicornis
F: Porcellionidae

Often living alongside humans, especially in lime-rich habitats, this distinctly marked woodlouse is native to Europe but has invaded North America.

⅜–¾ in
1–1.8 cm

COMMON PILL WOODLOUSE
Armadillidium vulgare
F: Armadillidiidae

Pill woodlice are characterized by their ability to roll into a ball when disturbed. This species is widespread across Eurasia and introduced elsewhere.

7½–14 in
19–36 cm

GIANT DEEPSEA ISOPOD
Bathynomus giganteus
F: Cirolanidae

A giant marine relative of woodlice, this species crawls along ocean beds, scavenging on dead animals and occasionally taking live prey.

8–14 in
20–36 cm

TIGER PRAWN
Penaeus monodon
F: Penaeidae

This widely farmed, giant Indo-Pacific prawn belongs to a group that does not brood its fertilized eggs, but releases them directly into the sea.

2–4 in
5–7.5 cm

SINGAPORE BAMBOO SHRIMP
Atropsis rafflesiana
F: Atyidae

From a family of mostly freshwater river shrimps, this is a filter-feeder from southeast Asia that eats particles caught on its fan-like front legs.

8–12 in
20–30 cm

STRIPE-LEG SPINY LOBSTER
Panulirus femoristriga
F: Palinuridae

Unlike true lobsters, spiny lobsters, such as this Indo-Pacific species, lack claws and have heavy, spiny exoskeletons and long, stout antennae.

PEACOCK MANTIS SHRIMP
Odontodactylus scyllarus
F: Odontodactylidae

Mantis shrimps of warm marine shallows are intelligent and formidable predators. This Indo-Pacific species uses "clubs" on its front limbs to smash the shells of crabs and snails.

1¼–7 in
3–18 cm

carapace

stalked eyes

clublike limbs deliver powerful blows

2½–4¼ in
7–11 cm

COMMON PRAWN
Palaemon serratus
F: Palaemonidae

A large, commercially important member of a family of shrimps with a jagged-edged carapace, this species inhabits northeast Atlantic coasts, frequenting the intertidal zone.

1¼–2 in
3–5 cm

AESOP SHRIMP
Pandalus montagui
F: Pandalidae

Males of this cold-water, North Atlantic shrimp sometimes change into females after 13–16 months. Other individuals remain male or female throughout their lives.

1 in
2.5 cm

SPOTTED CLEANER SHRIMP
Periclimenes yucatanicus
F: Palaemonidae

This Caribbean crustacean lives in sea anemones and — like many other reef-dwelling shrimps — cleans dead skin and parasites off visiting fishes.

3½–4¾ in
8–12 cm

WHITE-CLAWED CRAYFISH
Austropotamobius pallipes
F: Astacidae

Crayfish are small, mostly nocturnal, freshwater relatives of true lobsters. This is a European stream species and the only crayfish native to Britain.

2 in
5 cm

1½–2 in
3–5 cm

COMMON MARBLE SHRIMP
Saron marmoratus
F: Hippolytidae

A member of the hump-back shrimp family, this Indo-Pacific reef species is a nocturnal predator of smaller animals. It turns red at night.

long stiff antennae

COMMON SHRIMP
Crangon crangon
F: Crangonidae

This shallow-water crustacean is commercially fished on some European coasts. It habitually hides in sand with only eyes and antennae showing.

8–9½ in
20–24 cm

long spiny claws

2–8 in
5–20 cm

enlarged antennae

SCULPTURED SLIPPER LOBSTER
Parribacus antarcticus
F: Scyllaridae

Relatives of spiny lobsters, clawless slipper lobsters have flattened, platelike antennae. This nocturnal species lives on tropical reefs with sandy bottoms.

2–4½ in
5–12 cm

SERRATED SLIPPER LOBSTER
Ibacus brevipes
F: Scyllaridae

Like other slipper lobsters, this Indo-Pacific crustacean can swim rapidly away from predators by flapping its broad tail fan.

NORWAY LOBSTER
Nephrops norvegicus
F: Nephropidae

This North Atlantic crustacean tunnels in mud, often cohabiting with goby fish. It is a small-bodied true lobster, commercially marketed as langoustine or scampi.

»

» CRABS AND RELATIVES

12–16 in
30–40 cm

ROBBER CRAB
Birgus latro
F: Coenobitidae

The largest land-living arthropod, this hermit crab is a relative of squat lobsters and inhabits Indo-Pacific island forests, eating coconuts using massive pincers.

unequal-sized claws used for signaling

3/8 in
1 cm

PINK SQUAT LOBSTER
Lauriea siagiani
F: Galatheidae

Many tropical squat lobsters are associated with specific reef organisms. This tiny, hairy Indonesian species lives on *Xestospongia* vase sponges.

2¾–3½ in
7–9 cm

BLUE-STRIPED SQUAT LOBSTER
Galathea strigosa
F: Galatheidae

Slender-clawed squat lobsters such as this European species are decapods (ten-legged), but the last leg pair is reduced, making them appear eight-legged.

¾ in/2 cm

anemone attached to shell

ANEMONE PORCELAIN CRAB
Petrolisthes ohshimai
F: Porcellanidae

Porcelain Crabs are tiny, eight-legged decapods more closely related to squat lobsters than true crabs. This Indo-Pacific species lives in giant *Stichodactyla* anemones.

5/16–½ in/8–12 mm

INDO-PACIFIC PEA CRAB
Pinnotheres sp.
F: Pinnotheridae

Tiny pea crabs complete their life cycle on or in the bodies of other marine invertebrates. This Philippine species lives on cup corals.

antenna

1½ in
4 cm

RED REEF HERMIT CRAB
Paguristes cadenati
F: Diogenidae

Hermit crabs inhabit discarded snail shells that accommodate their soft coiled abdomen. This species lives on Indo-Pacific and eastern Atlantic reefs.

5–8 in
13–20 cm

WHITE-SPOTTED HERMIT CRAB
Dardanus megistos
F: Diogenidae

This crustacean of the eastern Atlantic and Indo-Pacific coasts is a "left-handed" hermit crab, with an enlarged left claw.

2¼–4 in
6–10 cm

ANEMONE HERMIT CRAB
Dardanus pedunculatus
F: Diogenidae

This hermit crab of Indo-Pacific reefs always carries a *Calliactis* anemone on its shell, which shares its food and provides camouflaged protection.

2–2¾in
5–6.5cm

VELVET SWIMMING CRAB
Necora puber
F: Portunidae

Swimming crabs have paddlelike rear legs. This aggressive, red-eyed species is common at low shore level on rocky coasts in the northeast Atlantic.

BLUE SWIMMING CRAB
Portunus pelagicus
F: Portunidae

This Indo-Pacific swimming crab prefers sandy or muddy coastlines, with juveniles entering the intertidal zone. Like its relatives, it preys on other invertebrates.

2–2¾in
5–7cm

2–4in
5–10cm

shell-like carapace

EDIBLE CRAB
Cancer pagurus
F: Cancridae

The most commercially important European crab, this offshore species has a distinctive wide "pie-crust" carapace and can live for more than 20 years.

1½–3½in
4–9cm

SPOTTED CORAL CRAB
Carpilius maculatus
F: Carpiliidae

One of three related, brightly colored, coral-living crabs with many fossil relatives, this large species has been found in the Indian and Pacific oceans.

1½–2¼in
4–6cm

WARTY BOX CRAB
Calappa hepatica
F: Calappidae

A tortoiselike crab, this Indo-Pacific, sand-burrowing species habitually shields its face with its claws, earning it the alternative name of shame-face crab.

1½–2in
4–5cm

SPONGE CRAB
Dromia personata
F: Dromiidae

This Atlantic crab often carries sponge pieces to hide itself from predators. Its reduced hind legs are like those of the related, primitive hermit crabs.

¾–1¼in
2–3cm

PAINTED PEBBLE CRAB
Leucosia anatum
F: Leucosiidae

Belonging to a family of small, mostly diamond-shaped crabs with long claws, this colourful species occurs in the Indian Ocean.

12–16in
30–40cm

JAPANESE SPIDER CRAB
Macrocheira kaempferi
F: Inachidae

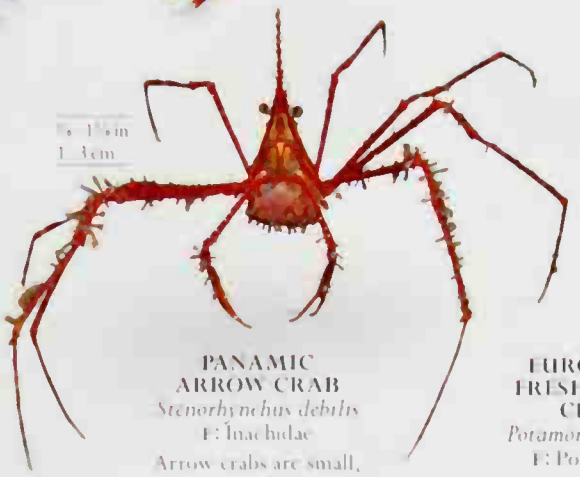
With legs spanning 13ft (4m), this is the world's biggest arthropod. It occurs in northwest Pacific waters and reputedly lives for up to 100 years.

3–4in
8–10cm

CHRISTMAS ISLAND RED CRAB
Gecarcoidea natalis
F: Gecarcinidae

This land-living crab lives in burrows only in the forests of Christmas Island. Huge numbers march in an annual migration to the sea for spawning.

¾–1¼in
1–3cm



PANAMIC ARROW CRAB
Stenorhynchus debilis
F: Inachidae

Arrow crabs are small, stalk-eyed, spiky-headed spider crabs. This eastern Pacific species is a reef-dwelling scavenger.

1¼–2in
4–5cm

EUROPEAN FRESHWATER CRAB
Potamon potamios
F: Potamidae

A member of a large family of Eurasian crabs from alkaline freshwaters, this southern European species spends much of its time on land.

eyes on stalks

ORANGE FIDDLER CRAB
Uca vocans
F: Ocypodidae

Fiddler crabs are burrowing beach crabs with an enlarged signaling claw in males. This species lives on muddy western Pacific shores.

¾–1¼in/2–4cm

RED SEA GHOST CRAB
Ocypode saratan
F: Ocypodidae

Ghost crabs, such as this Indo-Pacific species, are pale relatives of fiddler crabs. Both groups are stalk-eyed, fast-running beach dwellers.

furry claws

2–2¾in
5–6cm

CHINESE MITTEN CRAB
Eriocheir sinensis
F: Varunidae

Native to eastern Asia, this furry-clawed, burrowing river crab was introduced to North America and Europe, where it has become a pest.

INSECTS

Insects first appeared on land more than 400 million years ago and today they account for more species than any other class on the planet.

Insects have evolved diverse lifestyles and although most are terrestrial, there are also numerous freshwater species but almost no marine. They have a number of key features, such as a small size, an efficient nervous system, high reproductive rates, and—in many cases—the power of flight, which have led to their success.

Insects include (among others) beetles, flies, butterflies, moths, ants, bees, and true bugs. Yet for all their diversity, insects are remarkably similar. Evolution has modified the basic insect anatomy many times over to produce a multitude of variants based on three major body regions—the head, thorax, and abdomen. The head, made up of six fused segments, houses the brain and carries the major sensory organs: compound eyes, secondary light-receptive organs called ocelli, and the antennae. The mouthparts are modified according to diet, allowing the sucking of liquids or the chewing of solid foods.

The thorax is made up of three segments, each bearing a pair of legs. The posterior two thoracic segments usually each bear a pair of wings. The legs, which are each made up of a number of segments, can be greatly modified to serve a variety of functions from walking and running to jumping, digging, or swimming. The abdomen, which is usually made up of 11 segments, contains the digestive and reproductive organs.

PHYLUM	ARTHROPODA
CLASS	INSECTA
ORDERS	30
FAMILIES	About 1,000
SPECIES	About 1,000,000

DEBATE
HOW MANY SPECIES?

The actual number of insect species likely to exist far exceeds the number so far described, and many more are discovered each year. Estimates hover around 2 million. However, research based on sampling in species-rich rain forests suggests that there could be as many as 30 million species.

SILVERFISH

These primitive wingless insects of the order Thysanura have lengthy bodies that can be covered with scales. The head has a pair of long antennae and small eyes. The abdominal segments have small appendages (styles).

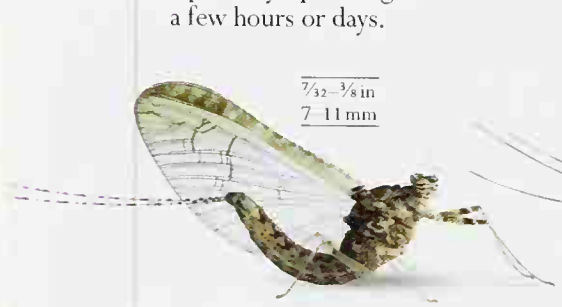
½ in/1.2 cm

SILVERFISH
Lepisma saccharina
F: Lepismatidae
This common domestic species can sometimes be a nuisance in kitchens, where it feeds on tiny scraps of dropped food.

FIREBRAT
Thermobia domestica
F: Lepismatidae
This insect is found worldwide and lives under stones and in leaf litter. Indoors, it prefers warm conditions and can be a pest in bakeries.

MAYFLIES

Ephemeroptera are soft-bodied insects with slender legs and two pairs of wings. The head has a pair of short antennae and large, compound eyes. The end of the abdomen has two or three long tail filaments. The life cycle is dominated by the aquatic nymphal stages—the nonfeeding adults live for only a few hours or days.



7/32–3/8 in
7–11 mm

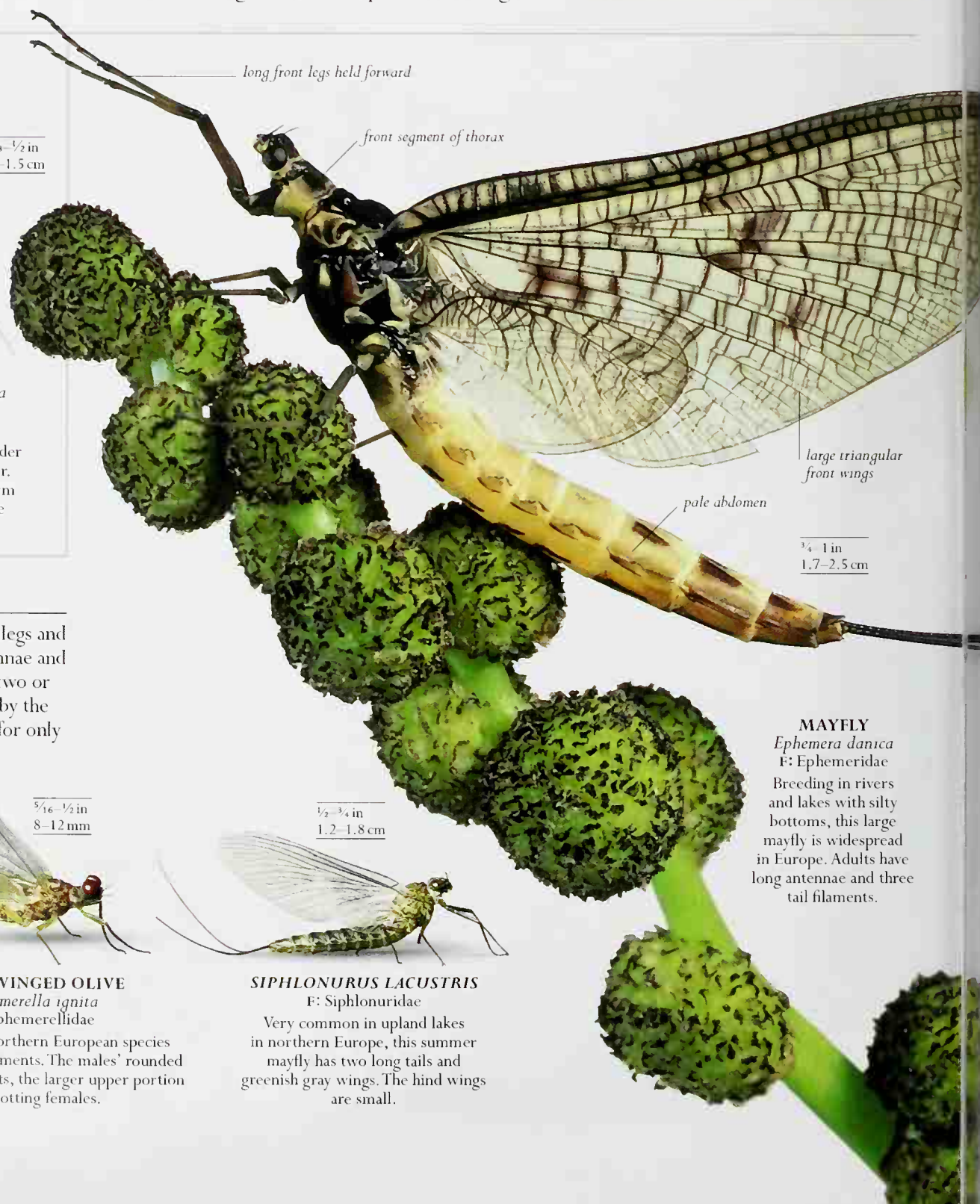
POND OLIVE
Cloeon dipterum
F: Baetidae
A widespread European species, this mayfly breeds in a range of habitats from ponds and ditches to troughs and water butts.

5/16–½ in
8–12 mm

BLUE-WINGED OLIVE
Ephemerella ignita
F: Ephemerellidae
Adults of this northern European species have three tail filaments. The males' rounded eyes have two parts, the larger upper portion for spotting females.

½–¾ in
1.2–1.8 cm

SIPHLONURUS LACUSTRIS
F: Siphlonuridae
Very common in upland lakes in northern Europe, this summer mayfly has two long tails and greenish gray wings. The hind wings are small.



¾–1 in
1.7–2.5 cm

MAYFLY
Ephemera danica
F: Ephemeridae
Breeding in rivers and lakes with silty bottoms, this large mayfly is widespread in Europe. Adults have long antennae and three tail filaments.

DAMSELFLIES AND DRAGONFLIES

These insects in the order Odonata have a distinctive long body with a mobile head and large eyes, giving good all-round vision. The adults have two pairs of similarly sized wings and are fast-flying hunters, the nymphs capture prey underwater using their specialized mouthparts. Dragonflies are robust with rounded heads, whereas damselflies are more slender with broader heads and widely separated eyes.

TWIN-SPOTTED SPIKETAIL
Cordulegaster maculata
F: Cordulegastridae

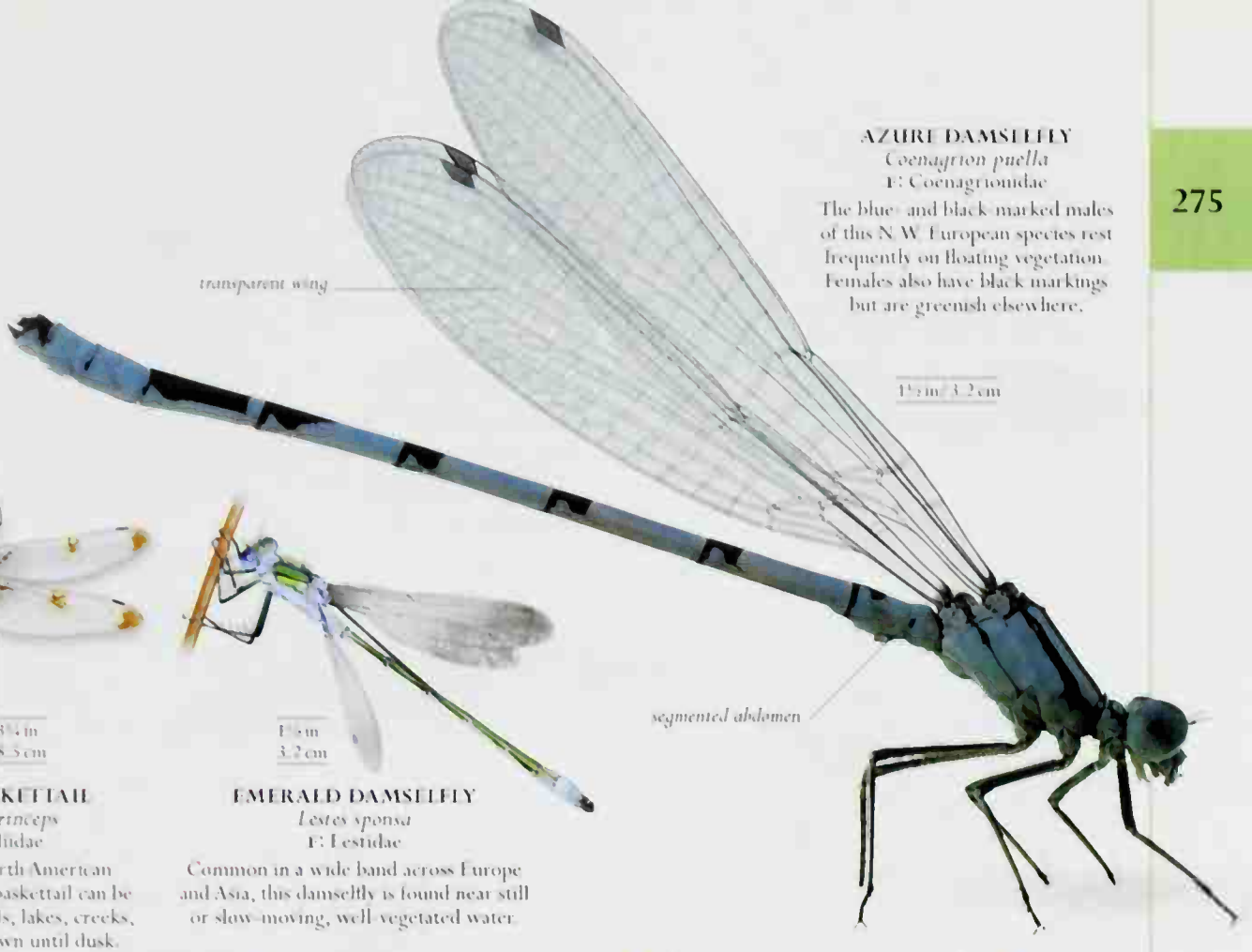
This dragonfly is found in the eastern USA and southeastern Canada, where it prefers clean streams in wooded habitats.

PRINCE BASKETTAIL
Epitheca princeps
F: Corduliidae

A widespread North American species, the prince baskettail can be seen patrolling ponds, lakes, creeks, and rivers from dawn until dusk.

EMERALD DAMSELFLY
Lestes sponsa
F: Lestidae

Common in a wide band across Europe and Asia, this damselfly is found near still or slow-moving, well-vegetated water.



AZURE DAMSELFLY
Coenagrion puella
F: Coenagrionidae

The blue- and black-marked males of this N.W. European species rest frequently on floating vegetation. Females also have black markings but are greenish elsewhere.

1¼ in/3.2 cm

BANDED DEMOISELLE
Calopteryx splendens
F: Calopterygidae

Males of this large damselfly from N.W. Europe have metallic blue-green bodies and blue wing bands. Females are metallic green and lack wing markings.

PLAINS CLUBTAIL
Gomphus externus
F: Gomphidae

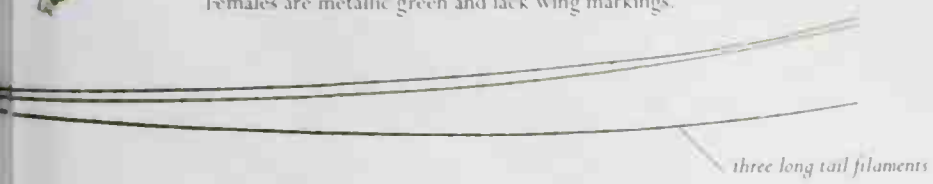
Flying on warm sunny days and breeding in slow-moving, muddy streams and rivers, this dragonfly is widespread in the USA.

COMET DARNER
Anax longipes
F: Aeshnidae

Occurring from Brazil to Massachusetts, the comet darner can be found over lakes and large ponds and has a steady, regular flight pattern.

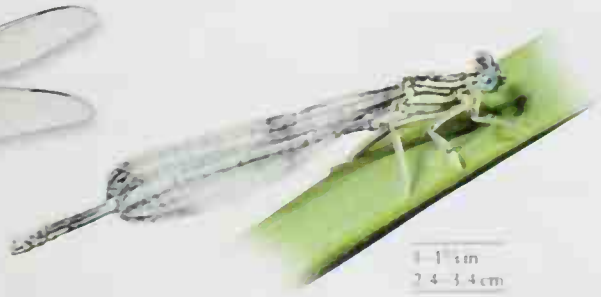
SWIFT RIVER CRUISER
Macromia illinoiensis
F: Macromiidae

This North American species patrols gravelly or rocky streams and rivers, but can also be seen flying away from water along roads or tracks.



GRAY PETALTAIL
Tachopteryx thoreyi
F: Petaluridae

A large dragonfly found in damp broad-leaved forests of the east coast of North America, this species breeds in boggy areas and seeps.



WHITE-LEGGED DAMSELFLY
Platycnemis pennipes
F: Platycnemididae

This damselfly from central Europe breeds in slow-moving, weedy canals and rivers. The tibia of the hind leg is expanded and appears slightly feathery.

BROAD-BODIED CHASER
Libellula depressa
F: Libellulidae

This central European species breeds in ditches and ponds. The abdomen of the male is blue above whereas that of the female is yellowish brown.

FLAME SKIMMER
Libellula saturata
F: Libellulidae

Favoring warm ponds, streams, and even hot springs, this species is common in the southwestern USA.

STONEFLIES

Members of the order Plecoptera are soft, slender-bodied insects with a pair of thin tail filaments and two pairs of wings. The nymphal stages are aquatic.

¾–1 in
2–2.8 cm

PERLA BIPUNCTATA
F: Perlidae

The males of this species, which favors stony streams in upland regions, have much shorter wings and can be half the size of the females.

11/32–½ in
0.9–1.3 cm

YELLOW SALLY
Isoperla grammatica
F: Perlodidae

Particularly common in limestone areas, this species prefers clean, gravel-bottomed streams and stony lakes. Males are shorter than females.

STICK AND LEAF INSECTS

These slow-moving herbivorous insects of the order Phasmatodea have stick- or leaflike bodies that may be smooth or spiny. Many are well camouflaged to avoid predators.

TWO-STRIPED STICK INSECT
Anisomorpha buprestoides
F: Phasmatidae

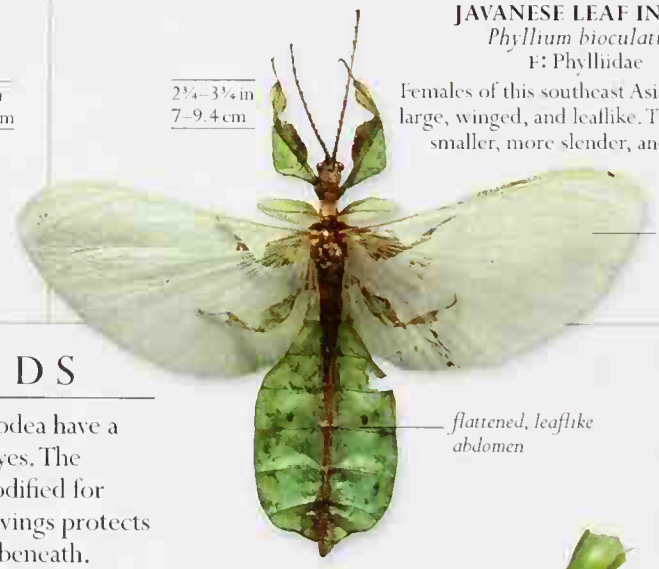
Found in the southern USA, this species can eject an acidic, defensive liquid from glands in the thorax.

1½–2½ in
4.2–6.8 cm

JUNGLE NYMPH STICK INSECT
Heteropteryx dilatata
F: Heteropterygidae

This impressive species is found in Malaysia. Females are flightless and green; males are smaller, winged, and brownish.

6 in
15.5 cm



2¾–3¾ in
7–9.4 cm

JAVANESE LEAF INSECT
Phyllium bioculatum
F: Phylliidae

Females of this southeast Asian insect are large, winged, and leaflike. The males are smaller, more slender, and brown.

large, fan-shaped hind wing

flattened, leaflike abdomen

EARWIGS

These slender, slightly flattened, scavenging insects belong to the order Dermaptera. They have short front wings with large fan-shaped hind wings folded beneath. The flexible abdomen ends in a pair of multipurpose forceps.

½ in
1.4 cm

COMMON EARWIG
Forficula auricularia
F: Forficulidae

This species can be found under bark and in leaf litter. The female cares for her eggs and feeds the young nymphs.

¾ in
1.8 cm

TAWNY EARWIG
Labidura riparia
F: Labiduridae

The tawny earwig, the largest European species, is especially common along sandy river banks and in coastal areas.

PRAYING MANTIDS

These predatory insects of the order Mantodea have a triangular, highly mobile head with large eyes. The enlarged, spined front legs are specially modified for snatching prey. A pair of toughened front wings protects the larger membranous hind wings folded beneath.

leaflike front wing

large compound eyes on a triangular head

extended prothorax

spiny, enlarged front femur

2–3 in
5–7.4 cm

COMMON PRAYING MANTIS
Mantis religiosa
F: Mantidae

The strike of a praying mantis lasts a fraction of a second, and impales the prey on the sharp spines of the front legs.

head crest

2¼ in
6 cm

CONEHEAD MANTID
Empusa pennata
F: Empusidae

A slender mantid with a distinctive head crest, this southern European species eats small flies and can be green or brown.

1¼–2¼ in
3–6 cm

ORCHID MANTIS
Hymenopus coronatus
F: Hymenopodidae

With its flower-mimicking color and legs resembling petals, this southeast Asian mantis is able to hide among foliage and ambush small insects.

CRICKETS AND GRASSHOPPERS

Orthoptera are mainly herbivorous. They have two pairs of wings, although some can be short-winged or wingless. The hind legs are often large and used for jumping. They sing by rubbing their front wings together or their hind legs on a wing edge.

COMMON FIELD GRASSHOPPER
Chorthippus brunneus
F: Acrididae

The common field grasshopper is typically found on short, dry, grazed grassland, where it is most active on sunny days.

WELLINGTON TREE WETA
Hemideina crassidens
F: Stenopelmatidae

Native to New Zealand, this nocturnal insect lives in rotten wood and tree stumps. It eats plant material as well as small insects.

AFRICAN CAVE CRICKET
Phaeophilacris geertsi
F: Rhaphidophoridae

This central African species is an omnivorous scavenger. Its long antennae are an adaptation to life in dark microhabitats.

LEAF-ROLLING CRICKET
Gryllacris subdebilis
F: Gryllacrididae

Found in Australia, this species has relatively long wings and very long antennae, which may be up to three times the length of the body.

DESERT LOCUST
Schistocerca gregaria
F: Acrididae

Crowding of nymphs after rain stimulates this African insect to transform from a solitary into a gregarious form. It swarms in billions, devastating crops.

OAK BUSH CRICKET
Meconema thalassinum
F: Tettigoniidae

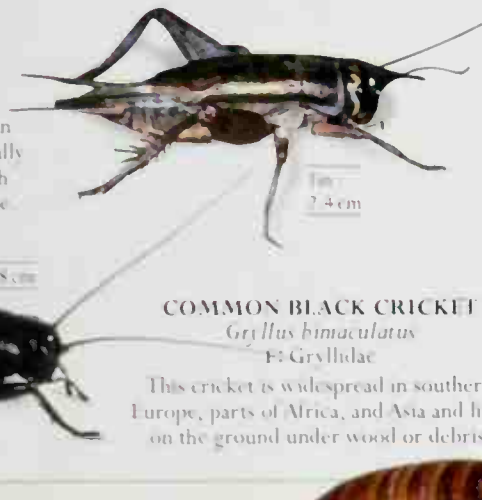
Found on a range of broadleaved trees, this European cricket feeds on small insects after dark. The female has a long, curved ovipositor.

MOLE CRICKET
Gryllotalpa gryllotalpa
F: Gryllotalpidae

This species from Europe uses its strong front legs to burrow, just like a miniature mole. It is found in meadows and banks near rivers, where the soil is damp and sandy.

FOAMING GRASSHOPPER
Dictyophorus spumans
F: Pyrgomorphidae

Bright colors advertise that this South African grasshopper is toxic to predators. It can also produce a noxious foam from its thoracic glands.



COMMON BLACK CRICKET
Gryllus bimaculatus
F: Gryllidae

This cricket is widespread in southern Europe, parts of Africa, and Asia and lives on the ground under wood or debris.

HOUSE CRICKET
Acheta domestica
F: Gryllidae

This nocturnal species makes an attractive chirping song. Originally from southwest Asia and North Africa, it has spread into Europe.

COCKROACHES

Members of the order Blattodea are scavenging insects, with a flattened oval body. The downward-pointing head is often largely concealed by a shieldlike pronotum and there are usually two pairs of wings. The tip of the abdomen has a pair of sensory prongs or cerci.

MADAGASCAN HISSING COCKROACH
Gromphadorhina portentosa
F: Blaberidae

This large, wingless cockroach is reared worldwide as a pet. The male has prominent bumps on the thorax for male-to-male combat.

DUSKY COCKROACH
Ectobius lapponicus
F: Blattellidae

Small and fast running, this European species can be found among leaf litter and occasionally in foliage. It has been introduced into the USA.

AMERICAN COCKROACH
Periplaneta americana
F: Blattidae

This species, which was originally from Africa, is now found worldwide. It lives on ships and in food warehouses.

TERMITES

These nest-building social insects of the order Isoptera live in colonies with different castes: reproductives (the kings and queens), workers, and soldiers. Workers are generally pale and wingless; reproductives have wings that are shed after a nuptial flight; and soldiers have large heads and jaws.

SUBTERRANEAN TERMITE
Coptotermes formosanus
F: Termitidae

Native to southern China, Taiwan, and Japan, this invasive species has now spread to other parts of the world, where it is a serious pest.

PACIFIC DAMPWOOD TERMITE
Zootermopsis angusticollis
F: Termopsidae

This termite, found along the Pacific coastal states of North America, nests in and feeds on decayed, fungus-infected wood.

abdomen is lined with sharp-tipped spines

large, strong defensive spines line insides of hind leg

claws for gripping and defense

wing pads

black-tipped spines on side of thorax and head

fewer spines

strong hind leg

tapering abdomen

< UNDERSIDE
The female's underside is dark green and, although it has fewer spines than the top surface, it is well protected by the spiny legs.

^ ADOLESCENT
The small, nonoverlapping wing pads show that this female is still a nymph—not yet sexually mature. At the next molt, when it sheds its skin, the nymph will become an adult, acquiring short, stubby wings and a functional ovipositor. After mating, the abdomen will swell as the eggs develop.

JUNGLE NYMPH STICK INSECT

Heteropteryx dilatata

This species is also known as the Malayan jungle nymph. Females are large, with bright green coloration on their upper surface and darker green below. The adult male is much smaller, more slender, and darker in color. Both have wings, but the female is flightless. Nymphs and adults feed on the foliage of a range of different plants, including durian, guava, and mango. Mature females with eggs can be very aggressive. If disturbed, they make a loud hissing sound using their short wings, and splay their strong, spiny hind legs in a defensive posture. If attacked, they will kick out. This lively species has become a popular pet worldwide.

SIZE Up to 6 in (15.5 cm)
HABITAT Tropical forest
DISTRIBUTION Malaysia
DIET Foliage of various plants

MOUTHPARTS >
At rest, the jaws are concealed behind two pairs of food-handling appendages called palps. These are covered with sensory organs, which enable the insect to taste the surface of the leaves it feeds on.

< COMPOUND EYE
Compound eyes—typical of insects—do not need to be as acute as those of many predatory arthropods, but they do need to be able to detect movement and potential enemies.

SEGMENTED BODY >
The tough, spiny plates that make up the body segments are joined by soft membranes that allow flexibility.

long, segmented antennae sense the immediate environment, including air movements

^ OVIPOSITOR
The female—which can lay up to 150 eggs in her lifetime—uses her ovipositor to lay her large eggs one at a time, concealed in any suitable substrate such as leaf litter.

^ > FOOT
The foot is made up of a number of short tarsal segments and a long, spiny terminal segment, which bears a pair of sharp, curved claws.

TRUE BUGS

Abundant and widespread in terrestrial and aquatic habitats, members of the order Hemiptera range from minute, wingless insects to giant water bugs capable of catching fish and frogs. The mouthparts are used for piercing and sucking up liquids such as plant sap, dissolved prey tissues, or blood. Many species are plant pests and some transmit disease.

1/32–1/16 in
1–2 mm

GREENHOUSE WHITEFLY
Trialeurodes vaporariorum
F: Aleyrodidae

This small mothlike bug is found in temperate regions worldwide and can be a serious pest of greenhouse crops.

3/16 in
5 mm

AMERICAN LUPIN APHID
Macrosiphum albifrons
F: Aphididae

Aphids such as this North American species can quickly infest plants because females can produce many offspring without fertilization.

5/16–3/8 in
8–10 mm

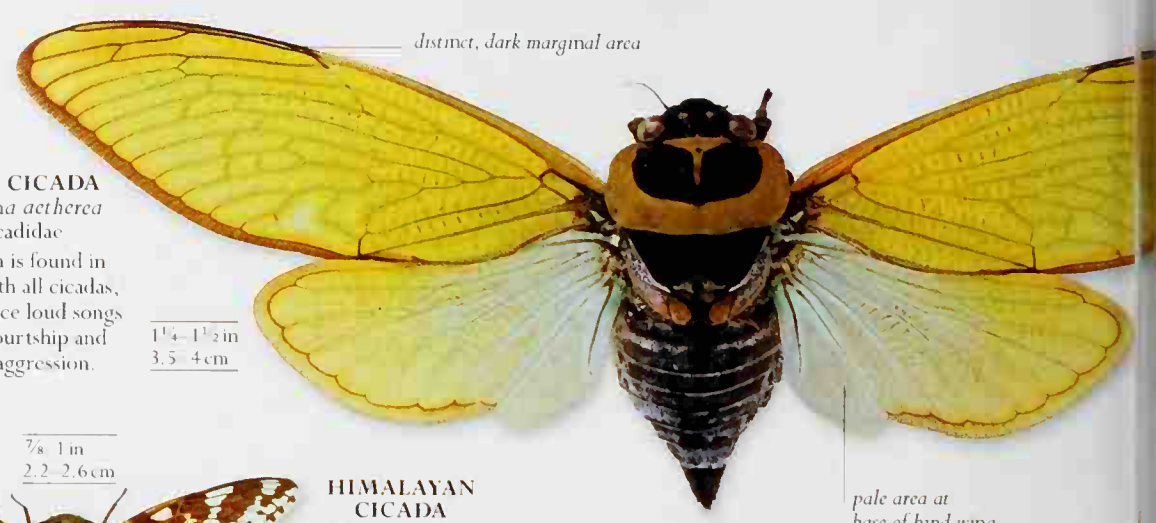
SPITTLE BUG
Aphrophora alni
F: Aphrophoridae

Commonly occurring on a wide range of trees and shrubs across Europe, this froghopper can vary in appearance from pale to dark brown.

3/8–1/2 in
1–1.2 cm

FROGHOPPER
Cecopis vulnerata
F: Cercopidae

The nymphs of this conspicuously colored European species live communally underground in a protective, frothy mass and feed on plant root sap.



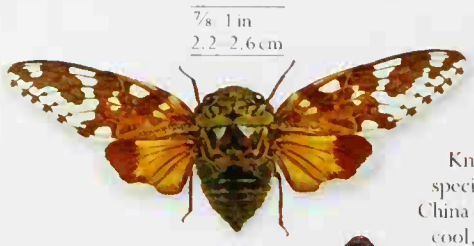
distinct, dark marginal area

INDIAN CICADA
Angamiana aetherea
F: Cicadidae

This cicada is found in India. As with all cicadas, males produce loud songs both for courtship and to signal aggression.

1 1/4–1 1/2 in
3.5–4 cm

pale area at base of hind wing



7/8–1 in
2.2–2.6 cm

HIMALAYAN CICADA
Pycna repanda
F: Cicadidae

Known in North India, this species is also found in parts of China and Nepal, where it prefers cool, alpine, deciduous forests.

1/4–5/16 in
6–8 mm

HORSE CHESTNUT SCALE
Pulvinaria regalis
F: Coccidae

Although commonly found on the bark of horse chestnut trees, this European scale insect will also attack a range of other deciduous species.

1/2 in
1–3 cm

LEAFHOPPER
Ledra aurita
F: Cicadellidae

Mottled coloration helps this flat-bodied leafhopper from northern Europe to blend with the lichen-covered bark of oak trees in its habitat.

7/32–11/32 in
7–9 mm

CICADELLA VIRIDIS
F: Cicadellidae

Found feeding on grasses and sedges in wet, boggy, or marshy areas in Europe and Asia, this leafhopper can also be found near garden ponds.

large eyespot

3 1/4 in/ 8 cm

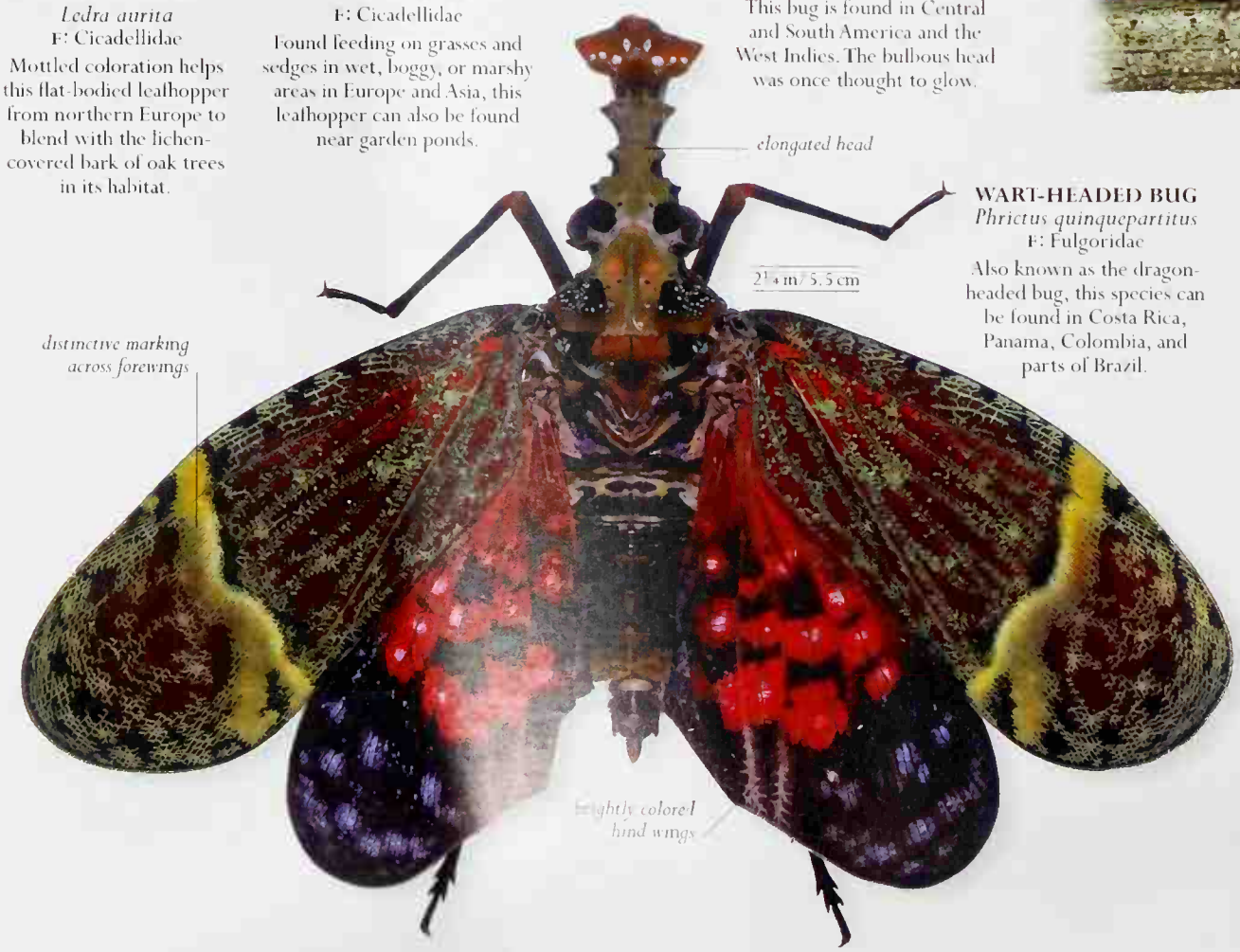
PEANUT-HEADED BUG
Fulgora laternaria
F: Fulgoridae

This bug is found in Central and South America and the West Indies. The bulbous head was once thought to glow.

3/8–1/2 in
1–1.2 cm

THORN BUG
Umbonia crassicornis
F: Membracidae

Found in Central and South America, almost the whole body is concealed under the enlarged, thornlike pronotum.



elongated head

2 1/4 in/ 5.5 cm

distinctive marking across forewings

brightly colored hind wings

WART-HEADED BUG
Phrictus quinquepartitus
F: Fulgoridae

Also known as the dragon-headed bug, this species can be found in Costa Rica, Panama, Colombia, and parts of Brazil.

1/16–1/8 in
2–3 mm

ASH PLANT LOUSE
Psyllopsis fraxini
F: Psyllidae

Found commonly on ash trees, the nymphs of this species cause red, swollen galls to form at the edges of leaves where they feed.

1/8–5/32 in
3–4 mm

THISTLE LACE BUG
Tingis cardui
F: Tingidae

This bug occurs in western Europe and feeds on spear, musk, and marsh thistles. The body is covered in powdery wax.

3/8–1/2 in
1–1.2 cm

EUROPEAN TORTOISE BUG
Eurygaster maura
F: Scutelleridae

This bug feeds on a wide range of grasses but can sometimes be a minor pest of cereal crops.

1/4 in
1.5 cm

HAWTHORN SHIELD BUG
Acanthosoma haemorrhoidale
F: Acanthosomatidae

This attractive European species feeds on the buds and berries of hawthorn and occasionally other deciduous trees such as laurel.

1/8–1/2 in
4 mm

COMMON FLOWER BUG
Anthocoris nemorum
F: Anthocoridae

This predatory bug can be found on a wide range of plants. Despite its small size it can pierce human skin.

1/8 in
3 mm

BIRCH BARK BUG
Aradus betulae
F: Aradidae

The flat body of this European bug allows it to live under the bark of birch trees, where it feeds on fungi.

1 1/4–4 in
3–10 cm

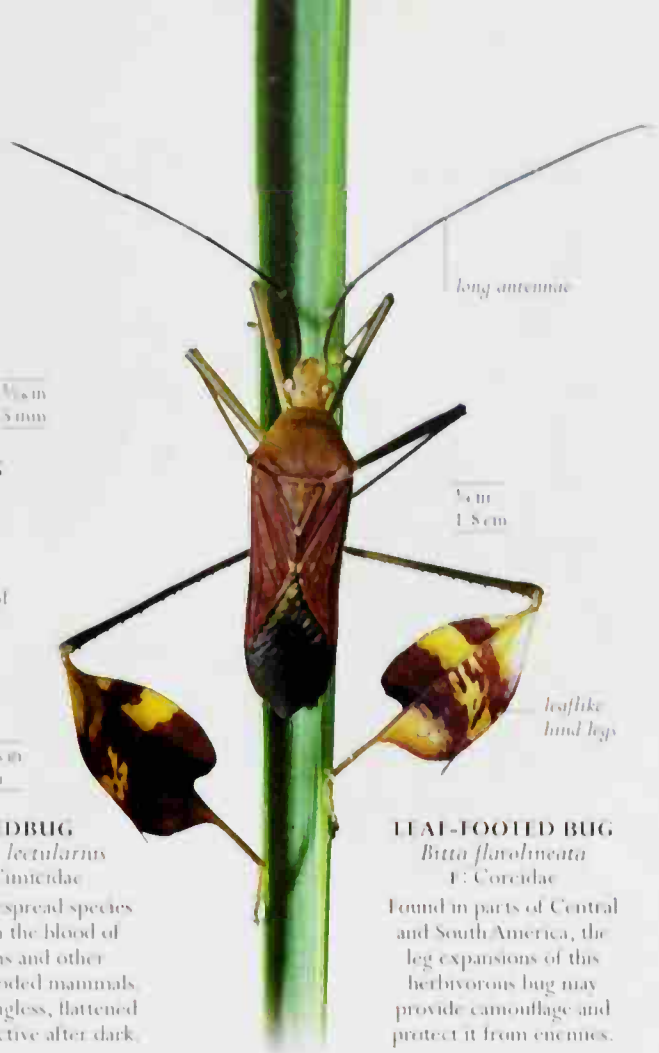
GIANT WATER BUG
Lethocerus grandis
F: Belostomatidae

Using its strong front legs and razor-sharp claws, this widespread bug can overpower larger vertebrate prey such as frogs and fish.

1/8–1/4 in
4–5mm

BEDBUG
Cimex lectularius
F: Cimicidae

This widespread species feeds on the blood of humans and other warm-blooded mammals. These wingless, flattened bugs are active after dark.



1/4 in
1.8 cm

LEAF-FOOTED BUG
Bitta flavolineata
F: Coreidae

Found in parts of Central and South America, the leg expansions of this herbivorous bug may provide camouflage and protect it from enemies.

3/8–1/2 in
1–1.2 cm

COMMON POND SKATER
Gerris lacustris
F: Gerridae

Widespread and immediately recognizable as it darts about on the surface of water, the pond skater locates prey by the ripples it sends out.

1/2 in/1.2 cm

WATER BOATMAN
Corixa punctata
F: Corixidae

Using its powerful, oarlike rear legs for swimming, this common European species feeds on algae and detritus in ponds.

3/8 in/1 cm

TOAD BUG
Nerthra grandicollis
F: Gelastocoridae

The warty surface and drab colouring of this African bug allow it to hide in mud and debris, where it ambushes insect prey.

1/8 in
3 mm

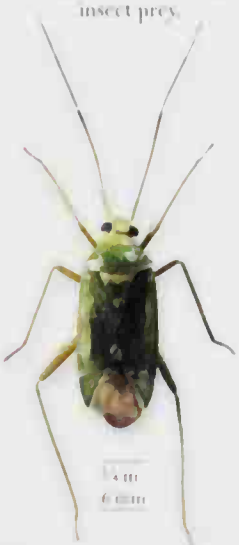
SAUCER BUG
Ilyocoris cimicoides
F: Naucoridae

The saucer bug traps air from the surface under its folded wings and hunts prey in the shallow margins of lakes and slow rivers. This species is from Europe.

1/4 in
1.2 cm

WATER MEASURER
Hydrometra stagnorum
F: Hydrometridae

This slow-moving European bug lives around the margins of ponds, lakes, and rivers and feeds on small insects and crustaceans.



1/4 in
6 mm

COMMON GREEN CAPSID
Lygocoris pabulinus
F: Miridae

This widespread bug can be a serious pest of a range of plants, including fruit crops such as raspberries, pears, and apples.

»

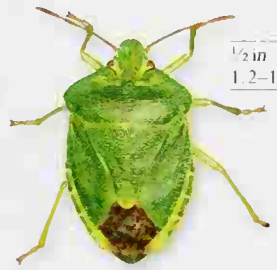
» TRUE BUGS

SCARLET SHIELD BUG
Eurydema dominulus
F: Pentatomidae

This European species, which can be red or orange, feeds on plants of the cress family and can be a pest of brassicas.

FIRE BUG
Pyrrhocoris apterus
F: Pyrrhocoridae

This unmistakable black and red bug is a gregarious, flightless species widespread in central and southern Europe. It feeds on seeds.

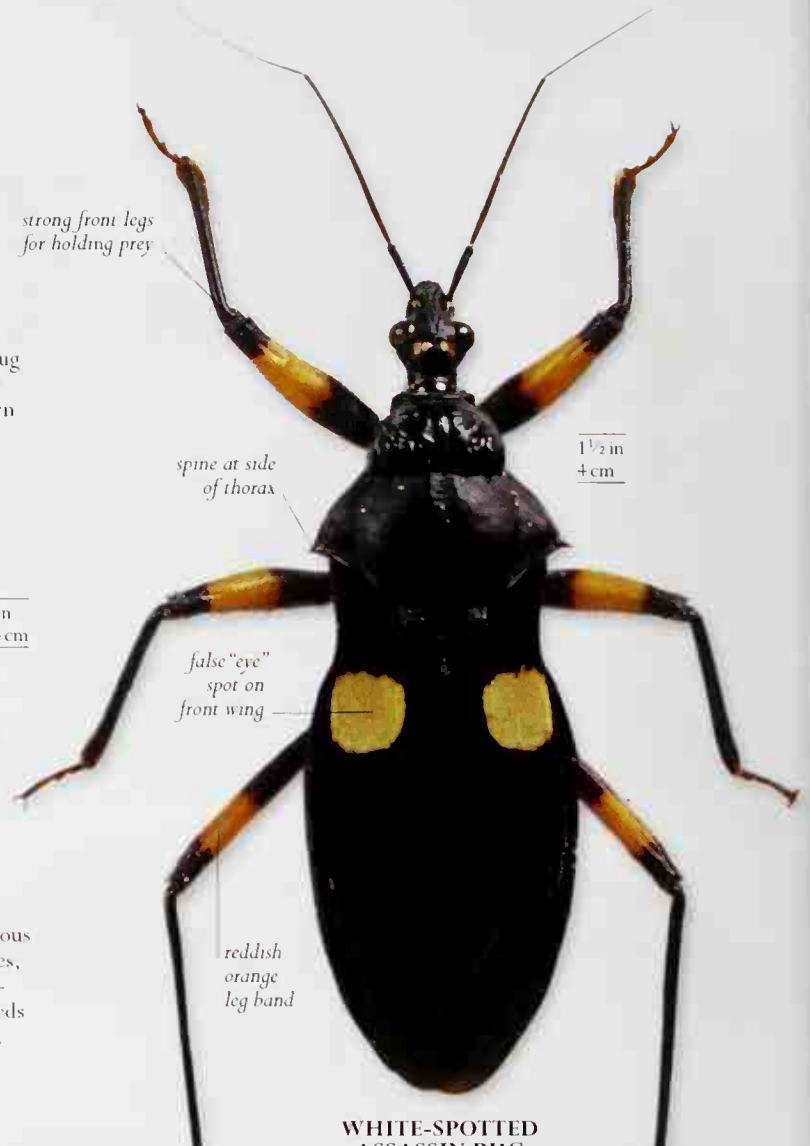


COMMON GREEN SHIELD BUG
Palomena prasina
F: Pentatomidae

This bug is very common and widespread across Europe. It feeds on a wide range of plants and can be a minor pest.

FOREST BUG
Pentatoma rufipes
F: Pentatomidae

Found on a range of deciduous trees, this European species, recognizable by its blunt-shouldered appearance, feeds on sap and small insects.



WHITE-SPOTTED ASSASSIN BUG
Platymeris biguttata
F: Reduviidae

Like all assassin bugs, this West African species has toxic saliva, but unlike many it can spit its saliva, causing temporary blindness.

WATER STICK INSECT
Ranatra linearis
F: Nepidae

Using its specialized, long front legs to catch prey, including small fish, this slender bug prefers deeper, well-vegetated pools.

WATER SCORPION
Nepa cinera
F: Nepidae

This aquatic bug crawls about in the margins of shallow pools to catch small prey. It breathes through a long respiratory tail.

COMMON BACKSWIMMER
Notonecta glauca
F: Notonectidae

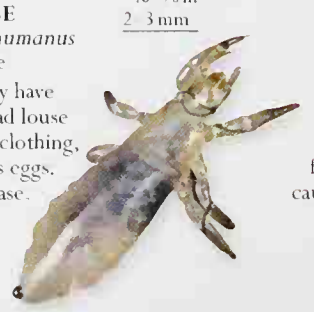
Found in ponds, lakes, canals, and ditches in Europe, this species is capable of taking vertebrate prey such as tadpoles and small fish. The underside faces up as it swims.

PARASITIC LICE

These wingless insects of the order Phthiraptera are ectoparasites, living on the bodies of birds and mammals. Their mouthparts are modified for chewing skin fragments or sucking blood, and their legs for gripping tightly to hair or feathers.

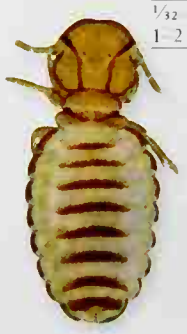
HUMAN HEAD LOUSE
Pediculus humanus capitis
F: Pediculidae

This louse glues its eggs, called "nits," to head hair. Infestation outbreaks are common among young children. A related species attacks chimpanzees.



HUMAN BODY LOUSE
Pediculus humanus humanus
F: Pediculidae

This subspecies may have evolved from the head louse after the invention of clothing, to which it glues its eggs. It transmits disease.



CHICKEN BODY LOUSE
Menacanthus stramineus
F: Menoponidae

Found worldwide as an ectoparasite of chickens, infestations of this pale, flattened chewing louse can cause feather loss and infection.

GOAT LOUSE
Damalinia caprae
F: Trichodectidae

Found worldwide on goats, this biting louse can also survive for a few days on sheep but is not able to breed on them.

BARKLICE AND BOOKLICE

Common on vegetation and in litter, insects of the order Psocoptera are small, squat, and soft-bodied. The head has threadlike antennae and bulging eyes. They eat microflora and some species are pests of stored products.

¼ in/ 6 mm

PSOCOCERASTIS GIBBOSA
F: Psocidae

Native to Europe and parts of Asia, this relatively large bark louse can be found on a wide range of deciduous and coniferous trees.

LIPOSCELIS LIPARIUS
F: Liposcelididae

This very widespread species prefers dark, damp microhabitats and can be a pest in libraries and granaries if the humidity is too high.

THRIPS

Members of the order Thysanoptera are tiny insects, typically with two pairs of narrow, hair-fringed wings. They have large compound eyes and distinctive mouthparts for piercing and sucking.

FLOWER THRIP
Frankliniella sp.
F: Thripidae

1/16–1/8 in/ 1–3 mm

Flower thrips are found all over the world and can be pests on crops such as peanuts, cotton, sweet potatoes, and coffee.

SNAKEFLIES

Snakeflies of the order Raphidioptera are woodland insects with a long prothorax, a broad head, and two pairs of wings. Adults and larvae eat aphids and other soft prey.

RAPHIDIA NOTATA
F: Raphidiidae

¼–⅜ in/ 1.6–1.8 cm

Found in deciduous or coniferous woodlands in Europe, this snakefly is usually associated with oak trees, where it eats aphids.

ALDERFLIES AND DOBSONFLIES

Megaloptera have two pairs of wings, which are held rooflike over the body when they are at rest. The aquatic larvae, which are predatory and have abdominal gills, pupate on land in soil, moss, or rotting wood.

EASTERN DOBSONFLY
Corydalus cornutus
F: Corydalidae

Found in North America, the male of this species has very long mandibles used for combat and for gripping the female.

4 in/ 10 cm

ALDERFLY
Sialis lutaria
F: Sialidae

The female of this widespread species lays a mass of up to 2,000 eggs on twigs or leaves near water.

½–¾ in/ 1.4–1.8 cm

LACEWINGS AND RELATIVES

Insects of the order Neuroptera have conspicuous eyes and biting mouthparts. The pairs of net-veined wings are held rooflike over the body at rest. The larvae have sickle-shaped mouthparts, which form sharp, sucking tubes.

½ in/ 1.4 cm

MANTISPA STYRIACA
F: Mantispidae

Like a miniature praying mantid, this, found in southern and central Europe, lives in lightly wooded areas, where it hunts small flies.

1½ in/ 4 cm

SPOON-WINGED LACEWING
Nemoptera sinuata
F: Nemopteridae

Common to areas of southeast Europe, this delicate species feeds on nectar and pollen at flowers in woodland and open grassland.

2 in/ 5 cm

OWLFLY
Libelloides macaronius
F: Ascalaphidae

Capturing insect prey in midair, this species will only fly on warm sunny days. It can be found in central and southern Europe and parts of Asia.

⅜–½ in/ 1–1.2 cm

GREEN LACEWING
Chrysopa perla
F: Chrysopidae

This widespread European species has a characteristic bluish green tinge and black markings and is commonly found in deciduous woodland.

GIANT LACEWING
Osmylus fulvicephalus
F: Osmylidae

This European species can be found among shady woodland vegetation by streams, where it eats small insects and pollen.

⅝ in/ 1.5 cm

ANTLION
Palpares libelluloides
F: Myrmeleontidae

This large, day flying, Mediterranean species with distinctively mottled wings can be found in rough grassland and warm scrubby habitats.

2–2¾ in/ 5–7 cm

male; have organs for clasping females

BEETLES

Members of the order Coleoptera—the largest insect order—range from minute to very large species. A distinguishing feature are the toughened front wings, called elytra, which meet down the body's midline and protect the larger membranous hind wings. Beetles occupy every aquatic and terrestrial habitat, where they are scavengers, herbivores, or predators.

VIOLET GROUND BEETLE
Carabus violaceus
F: Carabidae

A nocturnal hunter, this beetle is common in many habitats, including gardens. It is native to Europe and parts of Asia.

1–1⅖ in
2.8–3.4 cm

VIOLIN BEETLE
Mormolyce phyllodes
F: Carabidae

The shape of this Southeast Asian beetle allows it to squeeze under bracket fungi and tree bark, where it feeds on insect larvae and snails.

3¼–4 in
8–10 cm

⅛–3/16 in
3–5 mm

WOODWORM BEETLE
Anobium punctatum
F: Anobiidae

Adapted to breeding in timber in buildings and furniture, this species is now widespread and a serious pest.

1½ in
4 cm

JEWEL BEETLE
Chrysochroa chinensis
F: Buprestidae

This metallic species is native to India and southeast Asia, where its larvae burrow into the wood of deciduous trees.

⅜ in
1 cm

SOLDIER BEETLE
Rhagonycha fulva
F: Cantharidae

A common sight on flowers in the summer, this European beetle can be found in meadows and woodland margins.

7/32–⅜ in
7–10 mm

ANT BEETLE
Thanasimus formicarius
F: Cleridae

Associated with coniferous trees in Europe and northern Asia, the larvae and adults of this beetle prey on other beetle larvae.

5/16–⅜ in
8–10 mm

LARDER BEETLE
Dermestes lardarius
F: Dermestidae

Found in Europe and parts of Asia, this beetle feeds on animal remains but also lives in buildings, where it eats stored produce.

1/16–1½ in
0.2–4 cm

GREAT DIVING BEETLE
Dytiscus marginalis
F: Dytiscidae

This large beetle lives in weedy ponds and lakes in Europe and northern Asia. It eats insects, frogs, newts, and small fish.

1¼–1½ in
3–4 cm

CLICK BEETLE
Chalcolepidius limbatus
F: Elateridae

This beetle is found in woodland and grassland in the warmer parts of South America. Its larvae are predators in rotten wood and soil.

3/16–5/16 in
5–8 mm

WHIRLIGIG BEETLE
Gyrinus marinus
F: Gyrinidae

A common European species, this beetle is a surface-dweller on ponds and lakes. It uses its paddle-shaped legs to skim over the water.

⅜ in
1 cm

SCREECH BEETLE
Hygrobia hermanni
F: Hygrobiidae

This European beetle feeds on small invertebrate prey in slow-moving rivers and muddy ponds. It makes a squeaking noise if handled.

1 in
2.5 cm

LAMPYRIS NOCTILUCA
F: Lampyridae

This beetle is found across Europe and Asia, where it prefers rough grassland. The wingless female—known as the glow worm—emits a greenish light to attract a mate.

¼–⅜ in
6–10 mm

FOUR-SPOTTED HISTER BEETLE
Hister quadrimaculatus
F: Histeridae

Widespread across Europe, this beetle is found in dung and sometimes carrion, where it feeds on small insects and their larvae.

½–¾ in
1.5–2 cm

MINOTAUR BEETLE
Typhoeus typhoeus
F: Geotrupidae

This species is found in sandy areas in western Europe and buries sheep and rabbit droppings, on which the larvae feed, in burrows.

POWDERPOST BEETLE
Lyctus opaculus
F: Lyctidae
This North American beetle breeds in dry wood and reduces it to a fine powder.

NET-WINGED BEETLE
Platycis minuta
F: Lycidae
This small beetle is associated with decaying wood in mature and ancient woodland across Eurasia.

SEXTON BEETLE
Nicrophorus investigator
F: Silphidae
This species is found all over the Northern Hemisphere in woodland and grassland. It buries the carcass of small animals and the female lays an egg on it, providing food for the larva.

HERCULES BEETLE
Dynastes hercules
F: Dynastidae
The largest species of rhinoceros beetle (genus *Dynastes*), it feeds on rotting fruit in rain forests in Central and South America. Its larvae breed in decaying wood.

GOLIATH BEETLE
Goliathus cacicus
F: Cetoniidae
This species, the world's heaviest insect, lives in equatorial Africa, where the adults feed on ripe fruit or tree sap.

STAG BEETLE
Lucanus cervus
F: Lucanidae
This beetle lives in woodland in southern and central Europe. Its larvae develop over 4–6 years, mainly in decaying oak stumps. Males use their enlarged mandibles in contests over females.

POLLEN BEETLE
Glischrochilus hortensis
F: Nitidulidae
Often found feeding at fermenting sap flows or ripe fruit, this western European species is associated with decaying trees such as birch.

PHANAEUS DEMON
F: Scarabaeidae
Native to Central America, this metallic green beetle breeds in the dung of large herbivorous animals in grassland and pasture.

GOLD BEETLE
Plusiotis resplendens
F: Scarabaeidae
Found in upland areas of Costa Rica and Panama, this beetle lives in wet forest or plantations. The larvae breed in rotten tree trunks.

DEVIL'S COACH HORSE
Staphylinus olens
F: Staphylinidae
A European species found among woodland and garden leaf litter, this beetle raises its abdomen in a threatening display if disturbed.

EMUS HIRTUS
F: Staphylinidae
Native to southern and central Europe, this hairy rove beetle feeds on other insects attracted to cow and horse manure or carrion.

»

» BEETLES

1/8 in
3 mm

ANTLIKE BEETLE
Anthicus floralis
F: Anthicidae

Found across Europe and parts of Asia, this small beetle lives in and around decaying vegetation, manure, and compost heaps.

3/8–1/2 in
1–1.2 cm

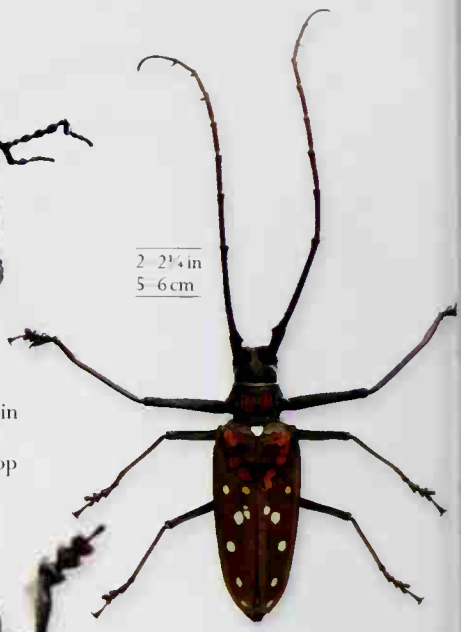
THICK-LEGGED FLOWER BEETLE
Oedemera nobilis
F: Oedemeridae

Often seen feeding on pollen at flowers in meadows, this beetle is native to southwest Europe. Its larvae develop inside plant stems.

1–1½ in
2.4–3.4 cm

BLACK OIL BEETLE
Meloe proscarabaeus
F: Meloidae

This European beetle is found in warm meadows, heaths, and coastal areas. The larvae develop inside the nests of wild bees.



2–2¼ in
5–6 cm

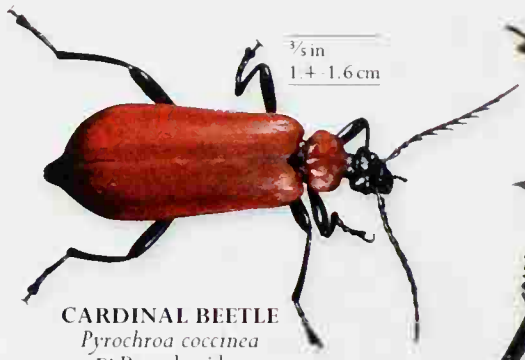
RED-SPOTTED LONGHORN BEETLE
Batocera rufomaculata
F: Cerambycidae

Also known as the mango borer or fig borer, this tropical species can be found throughout India and Southeast Asia.

½–¾ in
1.8–2.2 cm

GIBBIFER CALIFORNICUS
F: Erotylidae

This species is found in moist woodland in the southwestern USA. The larvae feed on fungi growing on trees and decaying wood.



⅜ in
1.4–1.6 cm

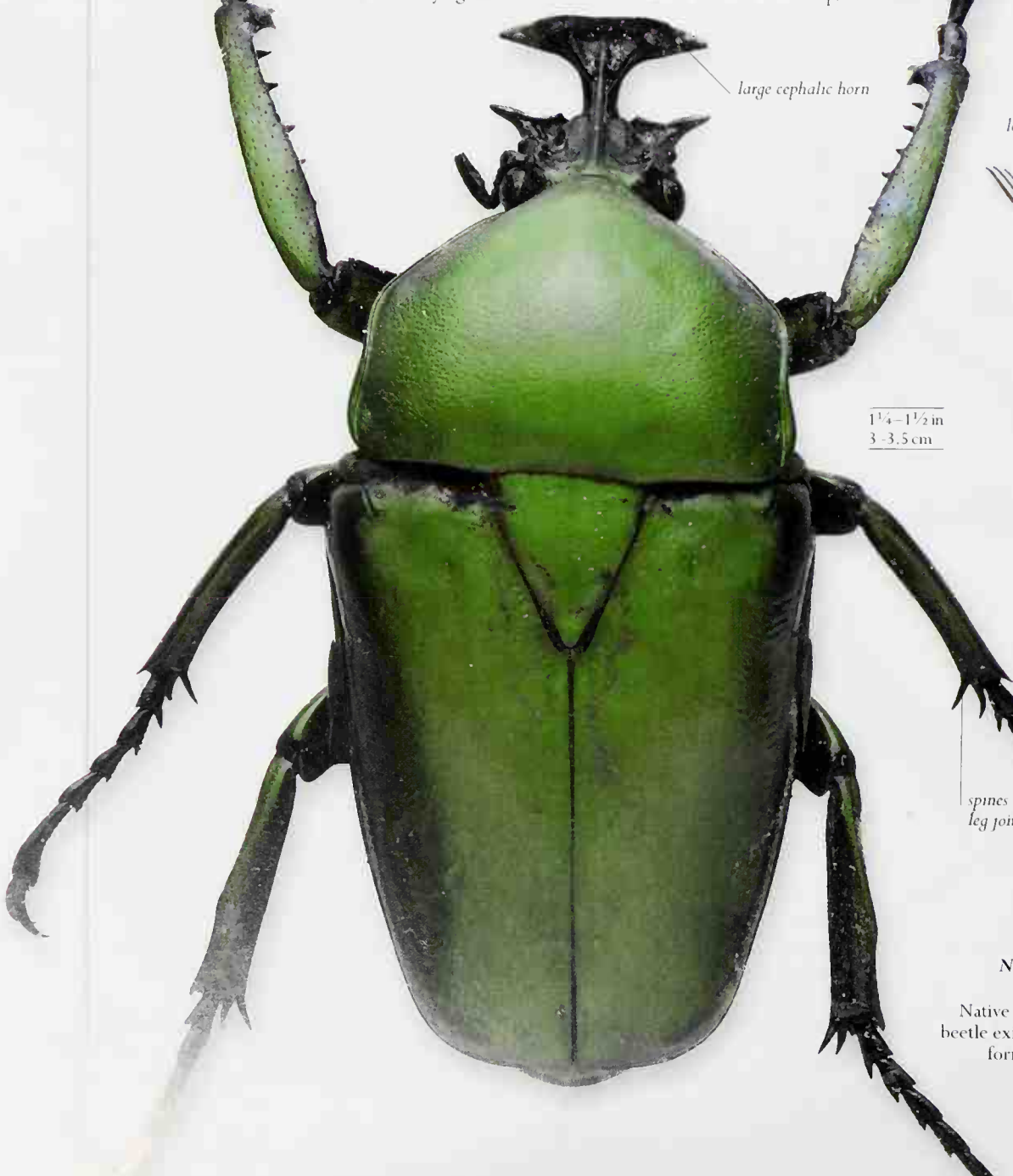
CARDINAL BEETLE
Pyrochroa coccinea
F: Pyrochroidae

This distinctive and somewhat flattened European beetle is often seen crawling on old tree stumps, inside which its larvae develop.

1¼–1½ in
2.8–3.6 cm

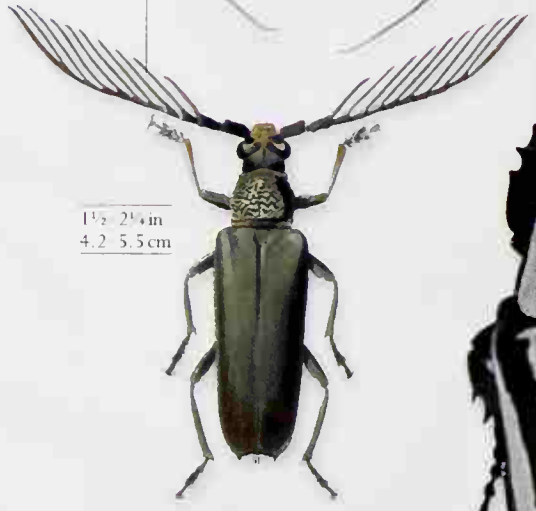
PHOSPHORUS JANSONI
F: Cerambycidae

Native to West Africa, the larvae of this beetle burrow into some economically important species such as the cola tree.



NEPTUNIDES POLYCHROUS
F: Cetoniidae

Native to East Africa, especially Tanzania, this beetle exists in a number of color forms. The blue form is considered to be a subspecies.



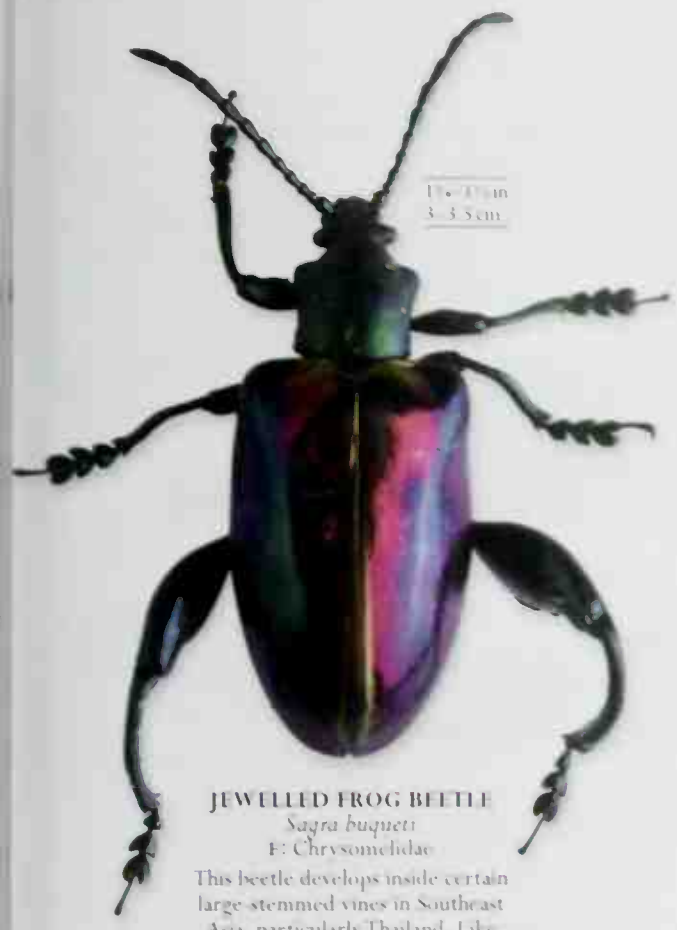
WALLACE'S LONGHORN BEETLE
Cyriopalus wallacei
F: Cerambycidae

This impressive beetle can be found in the rain forests of southeast Asia, where its larvae bore into certain trees.

1½–1¾ in
3.2–4.6 cm

DICRONORHINA DERBYANA
F: Cetoniidae

This beetle is found in southern and eastern parts of Africa, where the larvae feed on decaying plant matter and animal dung.



1½–1¾ in
3–3.5 cm

JEWELLED FROG BEETLE
Sagra buqueti
F: Chrysomelidae
This beetle develops inside certain large-stemmed vines in Southeast Asia, particularly Thailand. Like many attractive tropical species, they are sold to collectors.

¼–⅜ in
6–8 mm

SCARLET LILY BEETLE
Lilioceris lilii
F: Chrysomelidae
Originally from Europe and Asia, this striking pest has spread to other parts of the world where lilies are grown.

⅜–½ in
8–10 mm

EYED LADYBIRD
Anatis ocellata
F: Coccinellidae
This ladybird is native to Europe and is associated with coniferous trees, especially spruce and pine, where it feeds on aphids.

¼–⅜ in
6–9 mm

SEVEN-SPOT LADYBUG
Coccinella septempunctata
F: Coccinellidae
This species is very common in a wide range of habitats across Europe, and is now established in North America.

⅛–¼ in
4–5 mm

BROADBEAN WEEVIL
Bruchus rufimanus
F: Chrysomelidae
This species attacks field and broad bean crops. The adults feed on the pollen and their larvae tunnel into the seeds.

⅛–¼ in
4–5 mm

LARCH LADYBIRD
Aphidecta obliterata
F: Coccinellidae
This European species lives on conifers such as larch, fir, and pine, where it feeds on scale insects and conifer aphids.

⅛–¼ in
3–5 mm

TWENTY-TWO SPOT LADYBIRD
Psyllobora vigintiduopunctata
F: Coccinellidae
This European species lives on low-growing plants in meadows and, unlike most ladybirds, feeds on fungi such as mildews.

¾–1 in
2–2.4 cm

CHURCHYARD BEETLE
Blaps mucronata
F: Tenebrionidae
This flightless, ground-living species is usually active after dark and can be found in dark and damp places, where it eats decaying matter.

¾–1 in
1.8–2 cm

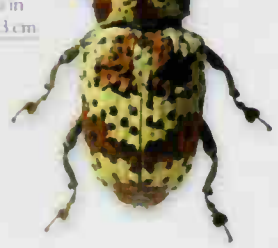
ONYMACRIS CANDIDIPENNIS
F: Tenebrionidae
Long legs and white wing cases help this beetle survive in the arid deserts along the southwestern coast of Africa.

1–1.2 in
2.5–3 cm

BAPTISIA WEEVIL
Trichapion rostrum
F: Brentidae
This small weevil feeds on white and cream wild indigo (*Baptisia*) seeds on the prairies of North America.

1½–2 in
3.5–5 cm

EUPHOLUS LINNEI
F: Curculionidae
Found on certain islands in eastern Indonesia, this spectacular weevil, like many others in the genus *Eupholus*, feeds on yams.



½–¾ in
1–1.3 cm

CRATOSOMUS RODDAMI
F: Curculionidae
This species lives in Central and South America. Its larvae are stem and bark borers of certain wild fruit trees.

1 in
2.6 cm

GIRAFFE-NECKED WEEVIL
Trachelophorus giraffa
F: Attelabidae
This beetle lives in the rain forests of Madagascar. It rolls the leaves of the *Dichaetanthera* tree with its neck, and the female lays her egg inside the roll.

⅛–¾ in
3–1.2 cm

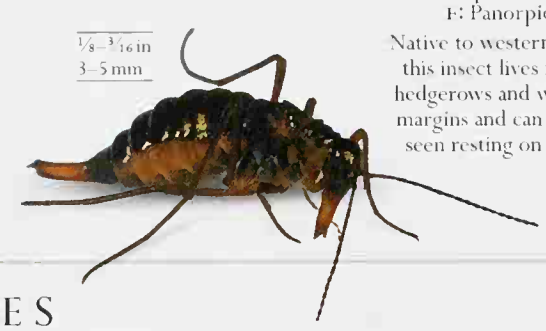
BLACK VINE WEEVIL
Otiorhynchus sulcatus
F: Curculionidae
Widespread in Europe, North America, and Australasia, it is a serious pest of a wide range of garden and cultivated plants.

SCORPIONFLIES

These predatory insects of the order Mecoptera generally have elongate and cylindrical bodies. The large, narrow wings may be clear or marked with spots or bands of dark color. Some species are short-winged or completely wingless. The heads, which have large eyes and threadlike antennae, are characteristically extended downward in the form of a beak, at the end of which are biting mouthparts.

¾ in
1.8 cm

COMMON SCORPIONFLY
Panorpa communis
F: Panorpidae
Native to western Europe, this insect lives in shady hedgerows and woodland margins and can often be seen resting on nettles.



⅛–3/16 in
3–5 mm

SNOW SCORPIONFLY
Boreus hyemalis
F: Boreidae
The adult of this small, wingless European insect can only be seen in autumn and winter. It breeds among moss.

FLEAS

Members of the order Siphonaptera, fleas are laterally flattened, wingless, blood-sucking ectoparasites of mammals and some birds. Their heads have short, piercing mouthparts and pairs of simple lateral eyes. The hind legs are enlarged for jumping.

⅛ in
3 mm

CAT FLEA
Ctenocephalides felis
F: Pulicidae
This species is very common worldwide. Also found on dogs, it can feed on the blood of several other animals, too—including humans.

TRUE FLIES

True flies belong to the order Diptera, and are recognized by a single pair of membranous front wings. The hind wings are reduced, forming a pair of balancing organs or halteres. Most flies are beneficial to humans as pollinators, predators, and recyclers, but wild and domestic animals and many people are affected by fly-borne diseases. Some flies are also crop pests.

¼–11/32 in
6–9 mm

MOSQUITO
Culex sp.
F: Culicidae
There are a large number of species in this genus worldwide. While some are disease vectors, many are essential in food chains.

1½–2 in
3.5–5 cm

GIANT BLUE ROBBER FLY
Blepharotes splendidissimus
F: Asilidae
This large fly is found in eastern Australia. It catches quite large prey on the wing and flies with a distinctive buzzing sound.

⅛ in
3 mm

AGROMYZA RONDENSIS
F: Agromyzidae
This small fly can be found all over Europe. The larvae make leaf mines in a wide variety of grass species.

⅜–⅔ in
1–1.6 cm

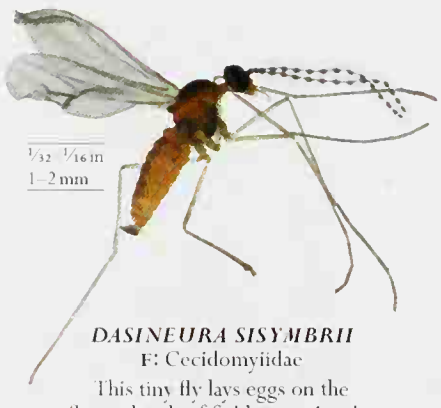
BEE FLY
Bombylius major
F: Bombyliidae
This species is widespread in temperate regions of the Northern Hemisphere. Adults are nectar-feeders and their larvae are parasites in bee nests.

⅜ in/1 cm

ST. MARK'S FLY
Bibio marci
F: Bibionidae
This common, springtime European fly can sometimes be seen in great numbers, flying clumsily and mating on grass and low vegetation.

5/16–⅜ in
8–11 mm

PLATYURA MARGINATA
F: Mycetophilidae
Widespread throughout western Europe, it lives in wooded areas. The larvae live inside rotting wood, where they eat other small insects.



1/32–1/16 in
1–2 mm

DASINEURA SISYMBRII
F: Cecidomyiidae
This tiny fly lays eggs on the flower heads of field cress. A pale, spongy gall develops, inside which the larvae feed.

7/32–11/32 in
7–9 mm

CABBAGE ROOT FLY
Delia sp.
F: Anthomyiidae
This small European fly can be a serious pest of wild and cultivated brassicas such as cabbage, turnip, and rape.

5/16–⅜ in
8–11 mm

BUZZER MIDGE
Chironomus plumosus
F: Chironomidae
This fly is found all across the Northern Hemisphere. The larvae are called bloodworms and live in muddy-bottomed ponds.

HOUSE FLY
Musca domestica
F: Muscidae

This species is found worldwide and is the most common fly around dwellings, where it transmits a number of disease-causing organisms to foodstuffs.

prominent red eyes

long legs can be shed if caught

1 in
2.5 cm

MARSH CRANE FLY
Tipula oleracea
F: Tipulidae

Originally from Europe, this crane fly is now present in North America and some upland parts of South America. It is often found by water.

MEROMYZA PRATORUM
F: Chloropidae

This fly occurs across the Northern Hemisphere, especially in sandy coastal regions. The larvae burrow in stems of marram grass and reed grass.

5/16–3/8 in
8–10 mm

red-orange wing base

1/4–7/32 in
6–7 mm

POECILOBOTHRUS NOBILITATUS
F: Dolichopodidae

This European species can be found in damp habitats near water. Males display in sunny patches by waving their wings.

1/32–1/4 in
4–6 mm

LESSER HOUSE FLY
Fannia canicularis
F: Fanniidae

Able to breed in almost any decaying, semiliquid matter, this species is particularly associated with human habitation.

3/32 in
4 mm

SIMULIUM ORNATUM
F: Simuliidae

This small fly lives in Europe and Asia but has been introduced elsewhere. The adults feed on animal blood and can transmit bovine onchocerciasis, a disease commonly known as river blindness.

1/8–3/16 in
3–5 mm

MOTH FLY
Clogmia albipunctata
F: Psychodidae

This very widespread fly species resembles a tiny moth. The larvae breed in dark, wet places such as drains, tree holes, and sewage.

1/2–3/4 in
1.4–1.8 cm

FLESH FLY
Sarcophaga carnaria
F: Sarcophagidae

Widely distributed through Europe and Asia, this fly feeds on nectar and liquids from rotting matter. The female lays live larvae on carrion.

males with longer eyestalks win fights for territory

SICUS FERRUGINEUS
F: Conopidae

This European fly lays eggs in the abdomen of certain bumble bees. The larvae develop as internal parasites, killing the host.

ROTHSCHILD'S ACHIAS
Achias rothschildi
F: Platystomatidae

Males of this Papua New Guinean fly have very elongate eyestalks. The head capsule is the biggest of any insect in the world.

1/2–3/4 in
1.5–1.8 cm

pale face with large compound eyes

1/2 in
1.4 cm

1/16 in
2 mm

FARMYARD MIDGE
Culicoides nubeculosus
F: Ceratopogonidae

This widespread European fly breeds in mud contaminated by dung or sewage. Adults suck the blood of horses and cattle.

1/16–1/2 in
1–1.2 cm

BLUEBOTTLE
Calliphora vicina
F: Calliphoridae

Found in Europe and North America, this species is especially common in urban areas and breeds in dead pigeons and rodents.

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YELLOW DUNG FLY
Scathophaga stercoraria
F: Scathophagidae

This very common fly is found in many parts of the Northern Hemisphere, where it breeds in cattle and horse dung. The larvae feed on the dung, while the adults prey on other insects attracted to the dung.

5/16–3/8 in
8–11 mm

fleshy, toothed proboscis for attacking prey

yellow, bristly body

1/2–3/5 in
1.3–1.5 cm

BANDED BROWN HORSE FLY
Tabanus bromius
F: Tabanidae

Widespread in Europe and the Middle East, this fly mainly attacks horses but will feed on some other animals, including humans.

5/32–3/16 in
4–5 mm

SEPSIS SP.
F: Sepsidae

These flies are common and widespread in a wide variety of habitats. The larvae develop in animal dung and rotting matter.

1/8 in/3 mm

COMMON FRUIT FLY
Drosophila melanogaster
F: Drosophilidae

A common laboratory animal, this widespread species has a distinctive dark patch on the abdomen and breeds in rotting fruit.

3/8–1/2 in
1–1.3 cm

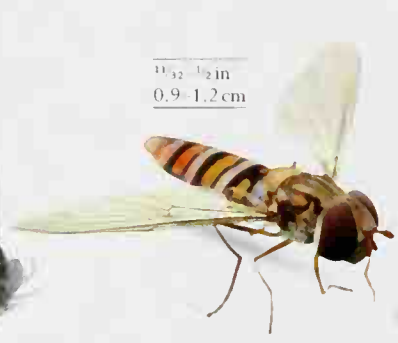
MARSH SNIPE FLY
Rhagio tringarius
F: Rhagionidae

This predatory fly can be found on low vegetation growing on damp scrubby or boggy ground throughout much of Europe.

5/16 in
8 mm

FOREST FLY
Hippobosca equina
F: Hippoboscidae

Occurring mainly in wooded areas in Europe and parts of Asia, this bloodsucking fly attacks horses, deer, and sometimes cattle.



11/32–1/2 in
0.9–1.2 cm

MARMALADE HOVER FLY
Episyrphus balteatus
F: Syrphidae

Very common in a variety of habitats including gardens, this European fly feeds on pollen and nectar. The larvae eat aphids.

3/8–1/2 in
1–1.2 cm

LEUCOZONA LEUCORUM
F: Syrphidae

This species from Europe can be found visiting flowers in damp woodlands in the spring and early summer. Its larvae prey on aphids.

2/5–1/2 in
1.1–1.3 cm

DRONE FLY
Eristalis tenax
F: Syrphidae

This European fly, which has been introduced to North America, is a mimic of the honey bee. The larvae breed in stagnant water.

5/32 in
4 mm

PENICILLIDIA FULVIDA
F: Nycteribiidae

Widespread in sub-Saharan Africa, this bloodsucking, wingless, ectoparasitic fly can be found on a wide range of bat species.

1/2 in
1.2 cm

SYRPHUS RIBESII
F: Syrphidae

The larvae of this nectar-feeding fly are major predators of aphids across Europe. Its coloration mimics that of wasps and bees, deterring predators.

2 1/4 in
6 cm

GAUROMYDAS HEROS
F: Mydidae

This South American insect, the world's largest fly, breeds in the nests of leaf-cutter ants, where the young are thought to eat scarab beetle larvae.

1in
2.5cm

RODENT BOT FLY
Cuterebra fontinella
F: Oestridae

This parasitic fly lives in North America. The larvae develop inside the bodies of rodents such as white-footed mice.

¼in
5mm

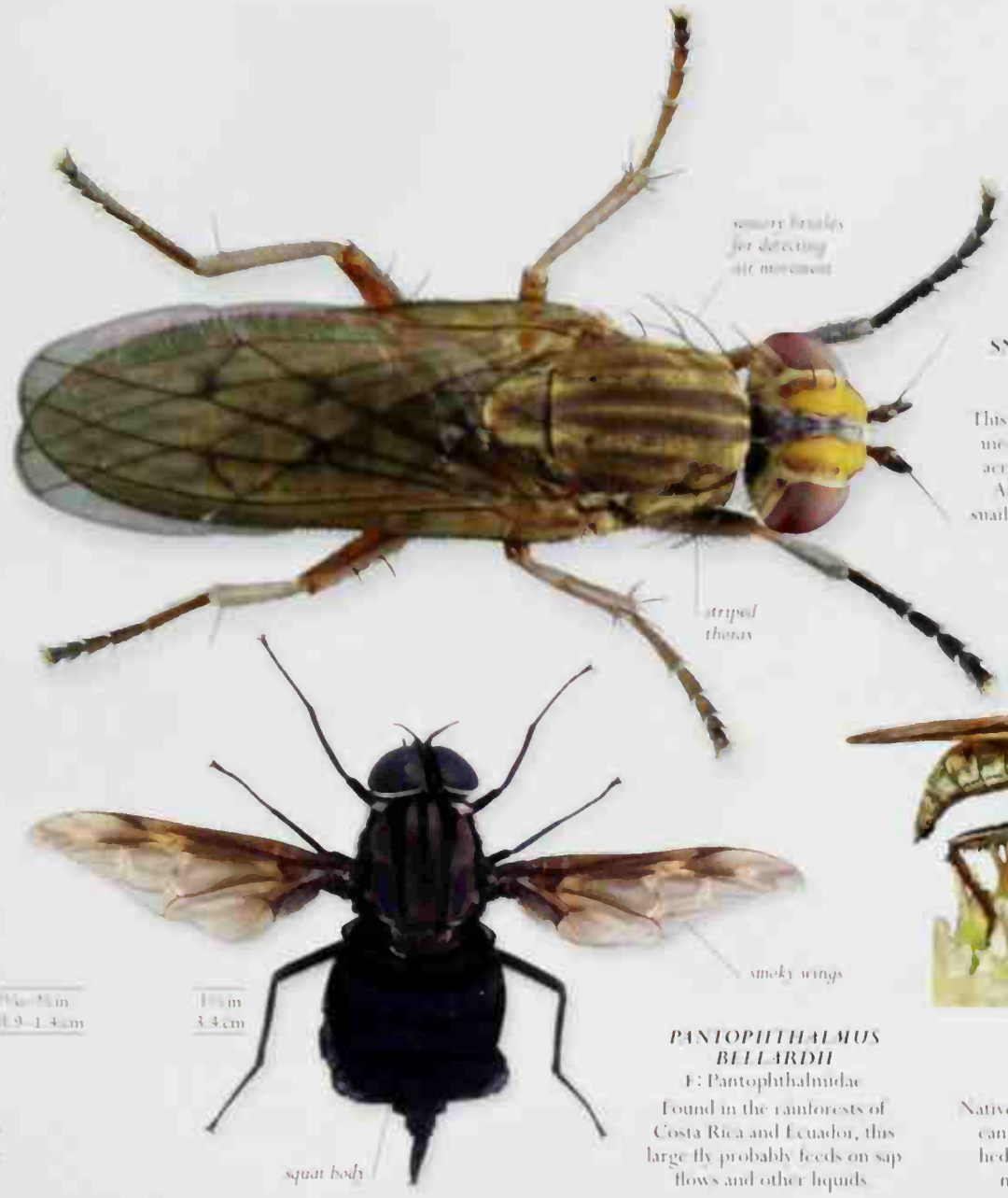
APPLE MAGGOT
Rhagoletis pomonella
F: Tephritidae

Native to North America, this fly is an apple pest but also attacks hawthorn, plums, cherries, and other related fruit trees.

⅜–½in
0.9–1.4cm

SAVANNAH TSETSE FLY
Glossina morsitans
F: Glossinidae

Confined to parts of Africa, this fly is one of the species that transmits the trypanosome parasite that causes sleeping sickness in humans.



¼–⅜in
4–6mm

SNAIL-KILLING FLY
Pherbellia cinerella
F: Sciomyzidae

This species is found in damp meadows and marshy areas across Europe and parts of Asia. The larvae prey on snails of the family Helicidae.

1¼in
3.4cm

PANTOPHTHALMUS BELLARDII
F: Pantophthalmidae

Found in the rainforests of Costa Rica and Ecuador, this large fly probably feeds on sap flows and other liquids.

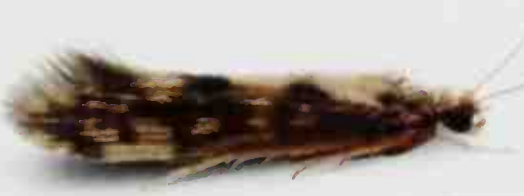
⅛–½in
1–1.2cm

DANCE FLY
Empis tessellata
F: Empididae

Native to Europe and Asia, this fly can be found in meadows and hedgerows, where it feeds on nectar and other insects.

CADDISFLIES

Closely related to the Lepidoptera, these slender, rather mothlike insects of the order Trichoptera are covered with hairs, not scales. The head has long, threadlike antennae and weakly developed mouthparts. The two pairs of wings are held tentlike over the body at rest. Caddisfly larvae are aquatic and often construct species-specific portable shelters out of small stones or plant fragments.



SALT AND PEPPER MICROCADDIS
Agraylea multipunctata
F: Hydroptilidae

¼–⅜in
3–4.5mm

This small caddisfly is widespread and common in North America. It has narrow wings and breeds in algae-rich ponds and lakes.

GREAT RED SEDGE
Phryganea grandis
F: Phryganeidae

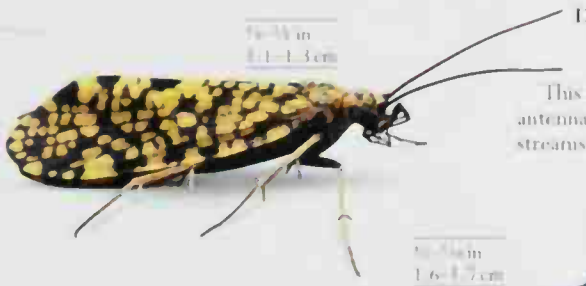
1in
3cm

This European caddisfly breeds in weedy lakes and slow rivers. The larvae make a case from cut leaf sections arranged in a spiral.

⅜in
1.5cm

MARBLED SEDGE
Hydropsyche contubernalis
F: Hydropsychidae

This caddisfly flies in the evening and breeds in rivers and streams. The aquatic larvae weave a net to catch food.



½–⅝in
1.1–1.3cm

DARK-SPOTTED SEDGE
Philopotamus montanus
F: Philopotamidae

This European caddisfly has shortish antennae and breeds in fast-flowing rocky streams. The larvae make tubelike nets on the undersides of rocks.

¾–⅞in
1.6–1.7cm

MOTTLED SEDGE
Glyphotaelius pellucidus
F: Limnephilidae

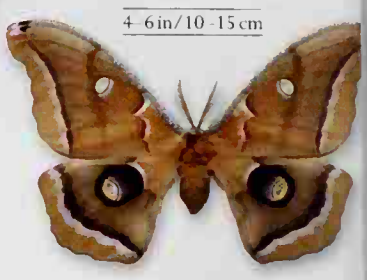
This European caddisfly breeds in lakes and small ponds. The larvae make a case out of fragments of withered tree leaves.

MOTHS AND BUTTERFLIES

Members of the order Lepidoptera are covered with minute scales. They have large compound eyes and a mouthpart called a proboscis. Larvae, known as caterpillars, pupate, metamorphosing into their adult form. Most moths are nocturnal and rest with their wings open; the majority of butterflies are diurnal and rest with their wings closed.

HERCULES MOTH
Coscinocera hercules
F: Saturniidae
Found in New Guinea and Australia, this moth is one of the biggest in the world. Only the male has the long hind wing tails.

AMERICAN MOON MOTH
Actias luna
F: Saturniidae
This lime-green North American moth has distinctive long hind wing tails. The caterpillars feed on a range of deciduous trees.



POLYPHEMUS MOTH
Antheraea polyphemus
F: Saturniidae
Common and widespread in the USA and southern Canada, this moth has large eyespots on the wings, to startle predators.

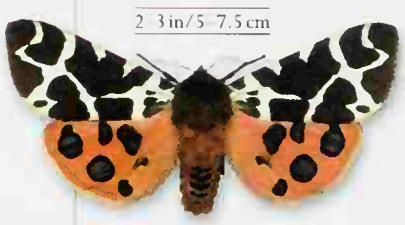
GIANT LEOPARD MOTH
Hypercompe scribonia
F: Arctiidae
The distribution of this striking moth extends from southeast Canada as far south as Mexico. The caterpillars feed on a variety of plants.

OAK EGGAR
Lasiocampa quercus
F: Lasiocampidae
Ranging from Europe to North Africa, the caterpillars of this moth feed on the foliage of hramble, oak, heather, and other plants.

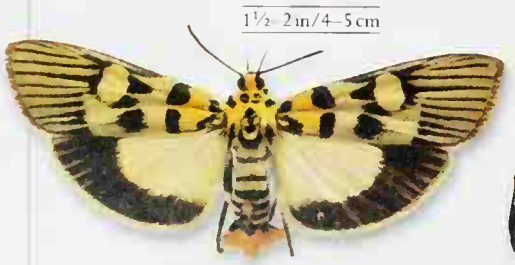
LAPPET MOTH
Gastropacha quercifolia
F: Lasiocampidae
Found in Europe and Asia, the specific name of this large moth refers to its resting appearance, which resembles a cluster of dead oak leaves.

PINE-TREE LAPPET
Dendrolimus pini
F: Lasiocampidae
This moth is widespread in coniferous forests across Europe and Asia, where the caterpillars feed on pine, spruce, and fir.

AUSTRALIAN MAGPIE MOTH
Nyctemera amica
F: Arctiidae
Widespread in Australia and also found in New Zealand, the caterpillars of this day-flying moth feed on plants such as groundsel and ragwort.

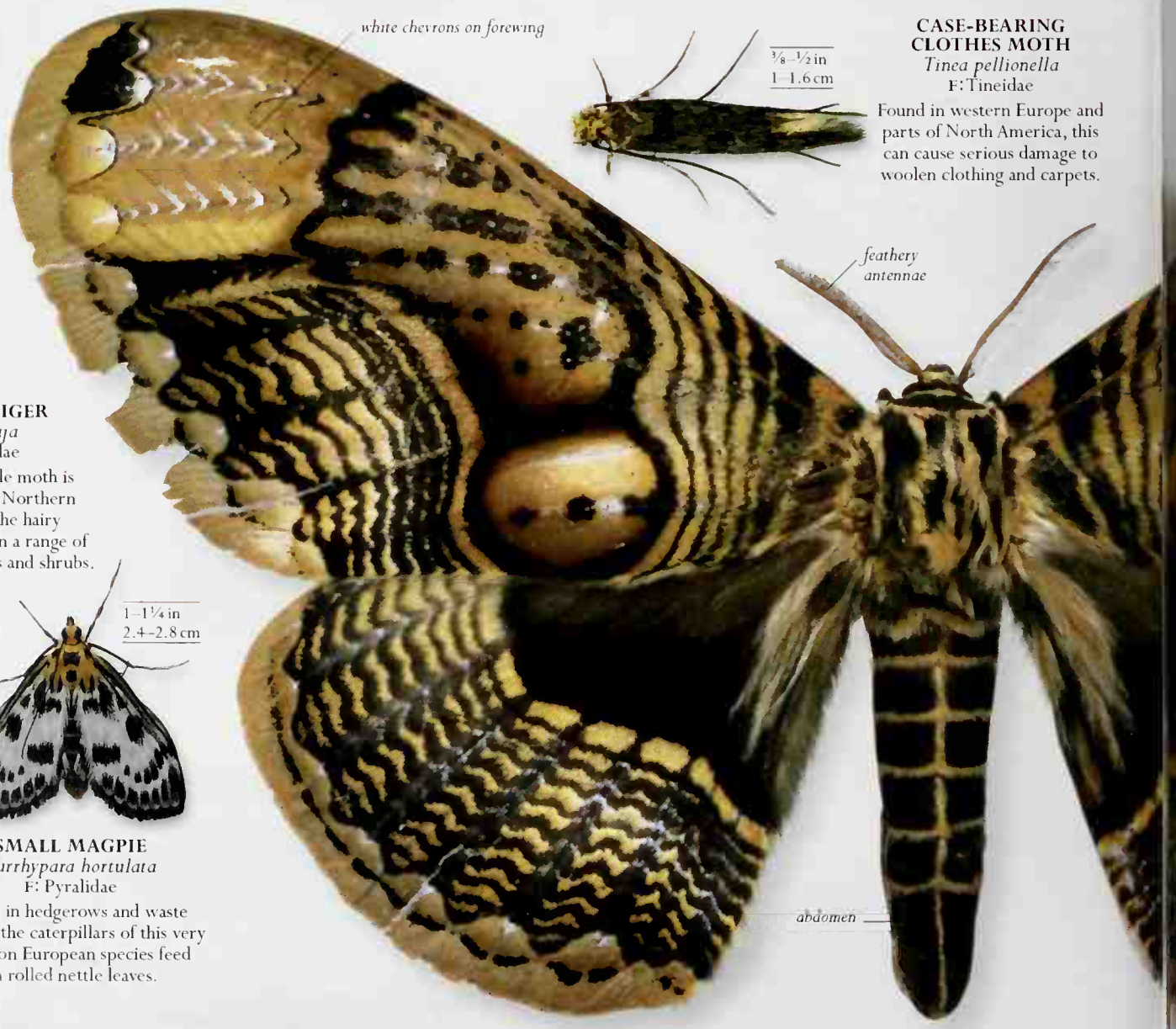


GARDEN TIGER
Arctia caja
F: Arctiidae
This unmistakable moth is found across the Northern Hemisphere. The hairy caterpillars feed on a range of low-growing plants and shrubs.



SNOUT MOTH
Vitessa suradeva
F: Pyralidae
This moth occurs in India, parts of southeast Asia, and New Guinea. The caterpillars feed in a web on young leaves of poisonous shrubs.

SMALL MAGPIE
Eurrhypara hortulata
F: Pyralidae
Found in hedgerows and waste ground, the caterpillars of this very common European species feed on rolled nettle leaves.



CASE-BEARING CLOTHES MOTH
Tinea pellionella
F: Tineidae
Found in western Europe and parts of North America, this can cause serious damage to woolen clothing and carpets.

9½–12 in / 24–31 cm

GIANT AGRIPPA
Thysania agrippina
F: Noctuidae

Found in Central and parts of South America, this species has one of the largest wingspans of any moth in the world.

2½–3¾ in
6.5–9.5 cm

DIVA MOTH
Divana diva
F: Castniidae

Found in tropical forests in South America, this day-flying species is well camouflaged at rest despite brightly colored hind wings.

ILIA UNDERWING
Catocala ilia
F: Noctuidae

This widespread species from North America has distinctive red-banded hind wings. The caterpillars feed on the foliage of oak trees.

2¼–3¼ in
7–8 cm

1–1¼ in / 2.5–3 cm

VAPOURER MOTH
Orgyia antiqua
F: Lymantriidae

Now found across the Northern Hemisphere, the female of this European species has tiny wings and is unable to fly.

2¼–4 in
6–10 cm

SILVER-SPOTTED GHOST MOTH
Sthenopis argenteomaculatus
F: Hepialidae

This species occurs in southern Canada and parts of the USA. The caterpillars mainly feed inside the roots of alder trees.

ACACIA CARPENTER MOTH
Xyleutes eucalypti
F: Cossidae

The robust, white caterpillars of this large and distinctive Australian moth burrow into the woody tissue of certain species of the acacia tree.

5–8 in
13–20 cm

large eyespot to scare predators

wavy pattern of black and orange lines

4–6½ in
10–16 cm

WALLICH'S OWL MOTH
Brahmaea wallichii
F: Brahmaeidae

This large moth occurs from northern India to China and Japan. The caterpillars eat the foliage of ash, privet, and lilac.

2–2¼ in
5–6 cm

LARGE EMERALD
Geometra papilionaria
F: Geometridae

This moth occurs across Europe and the temperate parts of Asia. The caterpillars feed mainly on the foliage of birch trees.

1¾–1½ in
3–4 cm

ARGENT AND SABLE
Rheumaptera hastata
F: Geometridae

The common name for this strikingly patterned moth from the Northern Hemisphere comes from the heraldic terms for silvery-white and black.

1½–2 in
4–5 cm

CLARA'S SATIN MOTH
Thalaina clara
F: Geometridae

The caterpillars of this moth, which occurs in eastern and southeastern Australia and northern Tasmania, feed on acacia foliage.

2¼–3 in
7–7.5 cm

COPPERY DYSPHANIA
Dysphania cuprina
F: Geometridae

Widespread across southeast Asia, this brightly colored moth flies during the day and is thought to be unpalatable to birds.

SILK MOTH
Bombyx mori
F: Bombycidae

Originating in China, the silk moth has been bred in captivity, on a diet of white mulberry leaves, for thousands of years. Its cocoon is used to make silk.

1½–2¼ in
4–6 cm

1–1¼ in
2.5–3 cm

WHITE PLUME-MOTH
Pterophorus pentadactyla
F: Pterophoridae

Common across Europe on dry grassland, waste ground, and gardens, the caterpillars of this distinctive species feed on hedge bindweed.

long legs

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» MOTHS AND BUTTERFLIES

2–2¼ in
5–6 cm

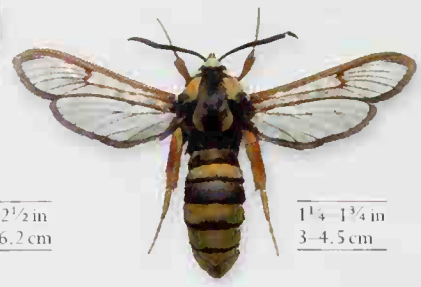
REGENT SKIPPER
Euschemon rafflesia
F: Hesperiidae

This brightly colored species is native to tropical and subtropical forests in eastern Australia, where it can be seen feeding at flowers.

1¾–2½ in
4.5–6.2 cm

GUAVA SKIPPER
Phocides polybius
F: Hesperiidae

This species can be found from southern Texas to as far south as Argentina. The caterpillars feed inside rolled-up guava leaves.



1¼–1¾ in
3–4.5 cm

HORNET MOTH
Sesia apiformis
F: Sesiidae

To deter predators, the adults of this moth look very similar to hornets but they are harmless. The caterpillars bore into the trunk and roots of poplars and willows.

1¾–2½ in
4.5–6.5 cm

BUFF-TIP
Phalera bucephala
F: Notodontidae

This moth is found in Europe and eastward to Siberia. At rest its folded wings wrap around its body for camouflage, resembling a broken-off twig.

2¼ in
5.5–6 cm

ELEPHANT HAWK MOTH
Deilephila elpenor
F: Sphingidae

This pretty, pinkish hawk moth is widespread in the temperate parts of Europe and Asia. The caterpillars feed on bedstraw and willowherb.

2¾–4¼ in
7–11 cm

VERDANT SPHINX
Euchloron megaera
F: Sphingidae

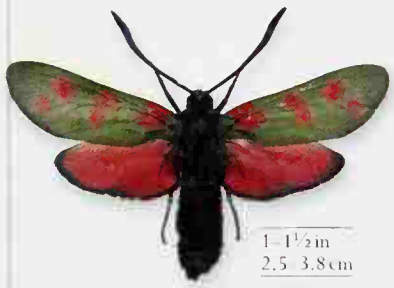
This distinctive moth is widespread throughout sub-Saharan Africa. The caterpillars feed on the foliage of creepers of the grape family.

COMMON MORPHO
Morpho peleides
F: Nymphalidae

This butterfly is widespread in tropical forests in Central and South America. Adults feed on the juices of rotting fruit.

3¾–6 in
9.5–15 cm

metallic blue color is attractive to mates



1–1½ in
2.5–3.8 cm

SIX-SPOT BURNET
Zygaena filipendulae
F: Zygaenidae

Brightly colored and distasteful to birds, this day-flying moth can be found in meadows and woodland clearings across Europe.

1¾–2 in
4.5–5 cm

LITTLE WOOD SATYR
Euptychia cymela
F: Nymphalidae

This woodland butterfly is found from southern Canada to northern Mexico. The caterpillars feed on grasses in clearings close to water.

3–4 in
7.5–10 cm

MONARCH BUTTERFLY
Danaus plexippus
F: Nymphalidae

A well-known migrant, this butterfly has spread from the Americas to many other parts of the world. The caterpillars feed on the milkweed plant.

2–2¼ in
5–6 cm

WHITE ADMIRAL
Ladoga camilla
F: Nymphalidae

This butterfly can be found across temperate Europe and Asia to Japan. The caterpillars feed on the foliage of the honeysuckle.

hind wing tails

long antennae

2¼–2¾ in
6–7 cm

QUEEN CRACKER
Hamadryas arethusa
F: Nymphalidae

The common name for this butterfly, found in forests from Mexico to Bolivia, refers to the clicking noise it makes when it flies.

2¾–3½ in
7–9 cm

PURPLE EMPEROR
Apatura iris
F: Nymphalidae

Found in woodland throughout Europe and Asia as far east as Japan, the male of this butterfly is iridescent purple whereas the female is dull brown.

3½–4¾ in
9–12 cm

INDIAN LEAF BUTTERFLY
Kallima inachus
F: Nymphalidae

With undersides that resemble a brown leaf, this species is perfectly camouflaged at rest with its wings folded. It occurs from India to southern China.

painted from wing

iridescent red wing marking

dark spots on hind wing

SMALL WHITE
Pieris rapae
F: Pieridae

This butterfly can now be found worldwide. The caterpillars feed on wild and cultivated cabbages and mustards, and can be pests.

1¼–2¼ in / 3.5–5.5 cm

3–3¾ in
7.5–9.5 cm

MADAGASCAN SUNSET MOTH
Chrysiridia rhipheus
F: Uraniidae

This colorful, day-flying moth, with iridescent wing scales, is endemic to Madagascar. It feeds on certain poisonous shrubs of the spurge family.

1½–2 in
4–5 cm

CALIFORNIA DOG-FACE
Zerene eurydice
F: Pieridae

This butterfly is restricted to parts of California and, sometimes, western Arizona. It breeds on a shrub called Napa False Indigo.

1½–2 in
4–5 cm

ORANGE TIP
Anthocharis cardamines
F: Pieridae

This butterfly can be found in meadows across temperate Europe and Asia as far as Japan. The caterpillars feed on lady's smock and garlic mustard.

2¾–3¾ in
7–9.5 cm

ORANGE-BARRED SULPHUR
Phoebis philea
F: Pieridae

The distribution of this butterfly extends from southern Brazil to Central America, southern USA, and sporadically farther north. The caterpillars feed on sennas.

1½–1¾ in
4–4.5 cm

TIGER PIERID
Dismorphia amphione
F: Pieridae

This colorful butterfly, which mimics unpalatable butterfly species for protection from predators, is widespread and common from Mexico to South America.

2¼–3¼ in
5.5–8 cm

SMALL POSTMAN
Heliconius erato
F: Nymphalidae

This butterfly is common along forest edges and open ground from Central America to southern Brazil. Caterpillars eat passionflower foliage.

4¾–6 in
12–15 cm

UNDERSIDE

OWL BUTTERFLY
Caligo idomeneus
F: Nymphalidae

The underside of this large species, native to South America, has prominent owl-like eyespots to deter predators when the butterfly is at rest.

2½–3 in
6.5–7.5 cm

BLACK-VEINED WHITE
Aporia crataegi
F: Pieridae

Occurring across Europe, North Africa, and Asia as far as Japan, this distinctive butterfly breeds on hawthorn and blackthorn.

2–2¾ in
5–7 cm

CLEOPATRA
Gonepteryx cleopatra
F: Pieridae

This species is common in countries around the Mediterranean, particularly in lightly wooded coastal areas. The caterpillars feed on species of buckthorn.

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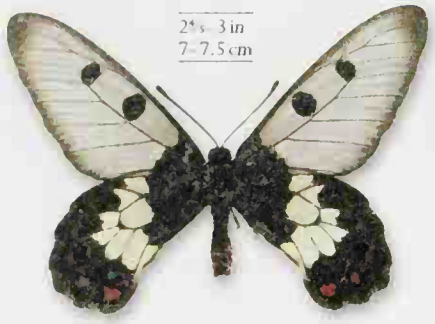
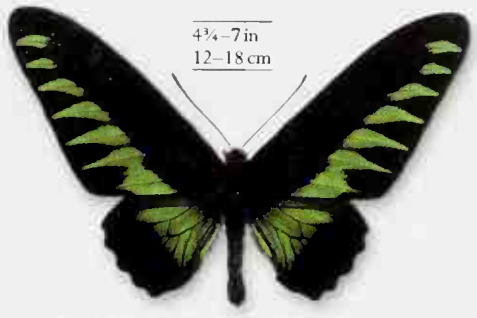


BIG GREASY BUTTERFLY
Cressida cressida
F: Papilionidae
This species is found in grassland and drier forests in Australia and Papua New Guinea, where its pipevine foodplants grow.

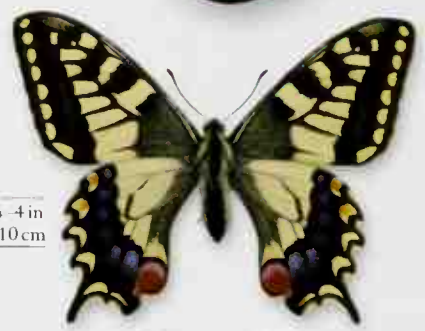
ZEBRA SWALLOWTAIL
Eurytides marcellus
F: Papilionidae
Found in damp woodlands in eastern North America, this butterfly has distinctive black and white markings. The caterpillars feed on pawpaw.

QUEEN ALEXANDRA'S BIRDWING
Ornithoptera alexandrae
F: Papilionidae
Found only in Southeast Papua New Guinea east of the Owen Stanley Ranges, this endangered species, the largest butterfly in the world, is now protected.



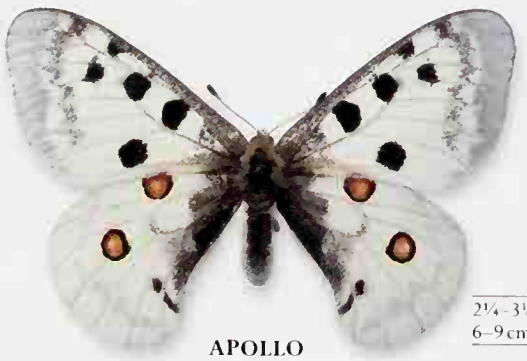
RAJAH BROOKE'S BIRDWING
Troides brookiana
F: Papilionidae
This butterfly lives in the tropical forests of Borneo and Malaysia, where the adults sip fruit juices and nectar. The caterpillars feed on pipevines.

CAIRNS BIRDWING
Ornithoptera priamus
F: Papilionidae
This large butterfly occurs from Papua New Guinea and the Solomon Islands to tropical northern Australia. The caterpillars eat pipevines.

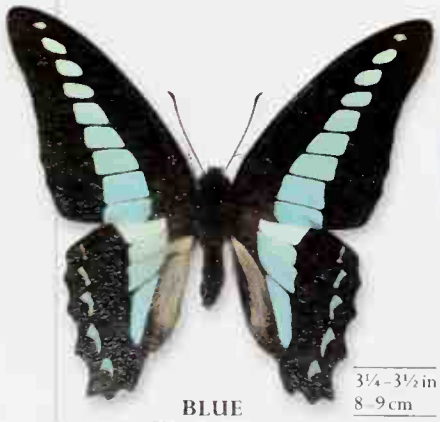


SWALLOWTAIL
Papilio machaon
F: Papilionidae
This species is found in wet meadow, marshland, and other habitats across the Northern Hemisphere. The caterpillars feed on various umbellifers.

GREEN DRAGONTAIL
Lamproptera meges
F: Papilionidae
This unmistakable butterfly, which hovers while it feeds at flowers, can be found from India to China and through South and Southeastern Asia.



APOLLO
Parnassius apollo
F: Papilionidae
This butterfly can be found in flower-rich meadows in mountainous regions of Europe and Asia. The caterpillars feed on stonecrop.



BLUE TRIANGLE
Graphium sarpedon
F: Papilionidae
Common and widespread from India to China, Papua New Guinea, and Australia, this butterfly feeds on nectar and drinks from puddles.

SCARCE SWALLOWTAIL
Iphiclides podalirius
F: Papilionidae
Despite its name, this species is quite widespread in Europe and across temperate Asia to China. The caterpillars feed on blackthorn.

SPANISH FESTOON
Zerynthia rumina
F: Papilionidae
This species lives in scrub, meadows, and rocky hillsides in southeast France, Spain, Portugal, and parts of North Africa. The caterpillars feed on species of birthwort.

3½–5½ in
9–14 cm

TIGER SWALLOWTAIL
Papilio glaucus
F: Papilionidae

This species is widespread in North America. The young caterpillars, which resemble bird droppings, feed on a variety of trees and shrubs.

SMALL COPPER
Lycaena phlaeas
F: Lycaenidae

Common in Europe, North Africa, and Asia as far as Japan, this species can also be found in North America. The caterpillars feed on sorrels and docks.

1–1⅛ in
2.5–3 cm

1½–1¾ in
3.5–4.5 cm

BROWN HAIRSTREAK
Thecla betulae
F: Lycaenidae

This species can be found in hedgerows, scrubland, and woodland across Europe and temperate Asia. The caterpillars feed at night on blackthorn.

1½–1¾ in
3–4 cm

BLUE THAROPS
Menander menander
F: Lycaenidae

This fast flying butterfly occurs in tropical forests from Panama to northern South America. Little is known about its life cycle or caterpillars.

1–1⅛ in / 2.5–3.5 cm

ADONIS BLUE
Lysandra bellargus
F: Lycaenidae

This European species can be found in chalky grassland, where the caterpillars feed on horseshoe vetch. The male is sky blue while the female is brown.

¾–1 in
2–2.5 cm

SONORAN BLUE
Philotes sonorensis
F: Lycaenidae

This rare butterfly is restricted to rocky washes and desert cliffs in California. The caterpillars feed on succulents known as stonecrop or "live-forever" plants.

1¼–1½ in
3–4 cm

DUKE OF BURGUNDY FRITILLARY
Hamearis lucina
F: Lycaenidae

This species ranges across central Europe as far as the Urals and prefers flower meadows, where its food plants, cowslip and primrose, grow.

SAWFLIES, WASPS, BEES, AND ANTS

Hymenoptera typically have two pairs of wings, joined in flight by tiny hooks. Apart from sawflies, they have a "wasp-waist" and females have an ovipositor that may sting. Many wasps are predatory or parasitic. Bees are vital pollinators and ants play a role in many ecosystems.

fine tufts on wing margin

7/32–13/32 in
7–9 mm

TENTHREDO ARCUATA
F: Tenthredinidae

Widespread in meadows, this distinctive black- and yellow-marked European sawfly lays its eggs on clovers.

STEM SAWFLY
Cephus nigrinus
F: Cephidae

This slender, all-black sawfly is widespread in western Europe. The larvae bore downward inside the stems of wild and some cultivated grasses.

7/32–13/32 in
7–9 mm

¾–⅞ in
1.8–2.2 cm

CIMBICID SAWFLY
Trichiosoma lucorum
F: Cimbicidae

This stout-bodied European sawfly is found in woodland, hedgerows, and scrubby areas. The larvae feed on birch and willow.

1½ in
3.5–4 cm

slender antennae

large head

HORNTAIL
Urocerus gigas
F: Siricidae

This impressive species can be found across the Northern Hemisphere. The female drills deep into pine trees to lay her eggs.

ovipositor

PERGID SAWFLY
Unknown sp.
F: Pergidae

These herbivorous insects are found in Australia and South America. Many species attack eucalyptus trees, and young larvae feed gregariously.

¾ in
2 cm

ROSE SAWFLY
Arge ochropus
F: Argidae

Recognizable by the black along the wing edge, this European sawfly visits flat-topped flowers to feed. The larvae feed on wild roses.

7/32–13/32 in
7–9 mm

LEAF ROLLING SAWFLY
Acanthalyda erythrocephala
F: Pamphiliidae

Originally found in Europe and Asia, this sawfly has spread to Canada. The larvae feed communally under silken webs or in rolled up foliage.

»

» SAWFLIES, WASPS, BEES, AND ANTS

1/32–1/8 in
1–3 mm

FIG WASP
Unknown sp.
F: Agaonidae
Fig wasps are found in tropical and subtropical regions. Many are essential pollinators and specific to certain species of fig.

1/8–3/8 in
3–10 mm

BRACONID WASP
Unknown sp.
F: Braconidae
Found worldwide, braconid wasps generally live as parasites on caterpillars and the larvae of beetles and flies. The females of some species have a long ovipositor.

3/16–3/10 in
5–6.5 mm

OAK APPLE GALL WASP
Biorhiza pallida
F: Cynipidae
This wasp emerges from root galls on oak trees in Europe and Asia. It lays eggs in buds, inducing the growth of oak apple galls.

3/4–9/10 in
2–2.2 cm

***LISSONOTA* SP.**
F: Ichneumonidae
The genus *Lissonota* contains many very similar wasps. This species drills into a trunk to lay its eggs in a wood-boring moth larva.

1 2/5–1 1/2 in
3.6–4 cm

GIANT WOOD WASP
Rhyssa sp.
F: Ichneumonidae
Found in pine forests across the Northern Hemisphere, these very large wasps drill into trees to lay their egg on the larvae of horntails.

7/10–3/4 in
1.8–2 cm

SPLENDID EMERALD WASP
Stilbum splendidum
F: Chrysididae
This large wasp from N. Australia lives as a parasite on the larvae of solitary mud-nesting wasps. They are known to visit flowers to feed.

5/32 in
4 mm

***TORYMUS* SP.**
F: Torymidae
This wasp uses her long ovipositor to drill through gall tissue and lay eggs on the developing larvae inside.

1/8–5/32 in
3–4 mm

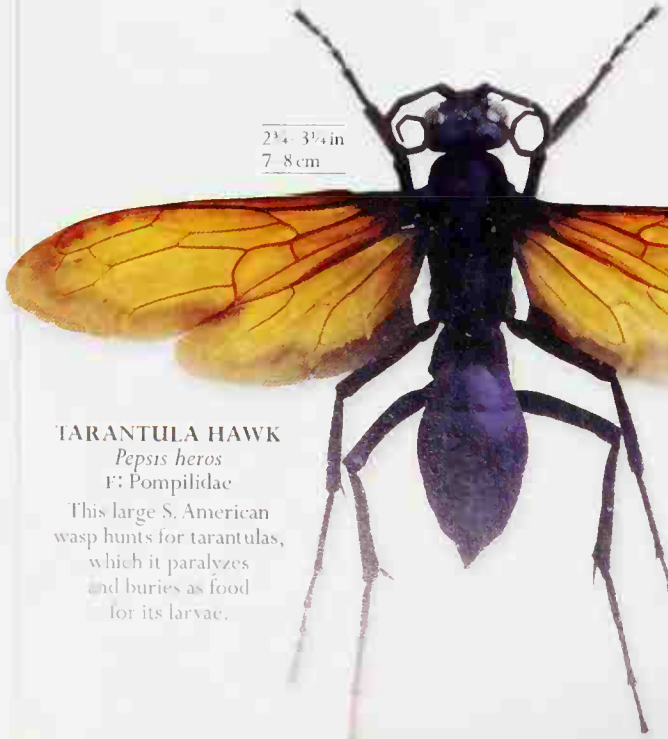
PTEROMALID WASP
Mesopolobus typographi
F: Pteromalidae
This European and Asian wasp is a hyperparasite; it is a parasite on another wasp that is itself a parasite on the larvae of bark beetles.

3/8–1/2 in
1–1.2 cm

CHALCID WASP
Chalcis sispes
F: Chalcididae
This wasp is found in Europe and parts of Asia, where it lives as a parasite on the aquatic larvae of large soldier flies.

1/2–3/5 in
1.3–1.5 cm

EUROPEAN BEEWOLF
Philanthus triangulum
F: Sphecidae
Found in southern and central Europe and North Africa, it makes a nest in sandy areas stocked with honey bees as food for its larvae.



2 3/4–3 3/4 in
7–8 cm

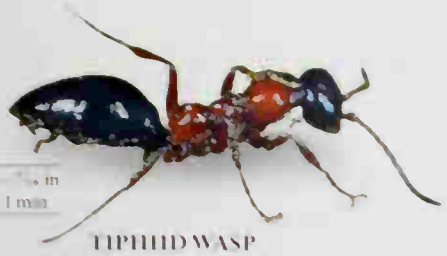
TARANTULA HAWK
Pepsis heros
F: Pompilidae
This large S. American wasp hunts for tarantulas, which it paralyzes and buries as food for its larvae.

1 3/4–2 1/4 in
4.5–5.5 cm

MAMMOTH WASP
Scolia procer
F: Scoliidae
Native to Borneo, Java, and Sumatra, this wasp paralyzes the larvae of scarab beetles and lays its eggs on them.

2/5–7/10 in
1.1–1.7 cm

VELVET ANT
Mutilla europaea
F: Mutillidae
This European species lives in sandy areas and rough grassland. The female is wingless, and the larvae eat the larvae of bumble bees.



TIPHIID WASP
Methocha ichneumonides
F: Tiphiidae

The wingless females of this European species live in sandy areas, where they are a parasite on the larvae of tiger beetles inside their burrows.

HORNET
Vespa crabro
F: Vespidae

This large social wasp lives in Europe and Asia and has been introduced elsewhere. It prefers woodland, where it makes its nest in hollow trees.

BUFF-TAILED BUMBLE BEE
Bombus terrestris
F: Apidae

This social bee of central and southern Europe and North Africa has been introduced elsewhere. It is an important crop pollinator.

very hairy body

COMMON WASP
Vespula vulgaris
F: Vespidae

Native to the Northern Hemisphere, this wasp feeds its young on insects and makes a paper nest from chewed wood fibers.

TAWNY MINING BEE
Andrena fulva
F: Andrenidae

Found in central Europe, this early spring bee makes a nest underground in grassy areas, raising a little mound of soil at the entrance.

HONEY BEE
Apis mellifera
F: Apidae

The western honey bee, an important crop pollinator, is now found worldwide. In the wild it nests in hollow trees, but is widely kept in domestic hives.

ORCHID BEE
Euglossa assarophens
F: Apidae

Like all orchid bees, this species lives in colonies in the rain forests of South America. Males collect oils and resins from orchids to attract a mate.

PLASTERER BEE
Colletes sp.
F: Colletidae

These solitary, ground-nesting bees are common across the Northern Hemisphere. They line their nests with a waterproof abdominal secretion.

GREAT CARPENTER BEE
Xylocopa latipes
F: Anthophoridae

Found all over southeast Asia, this large bee excavates nest cavities in tree branches or wooden beams and posts.

WOOD ANT
Formica rufa
F: Formicidae

Common throughout Europe, this ant is an important predator of insects in forests. It squirts formic acid from the rear of its abdomen as a defense.

LEAF-CUTTER ANT
Atta sp.
F: Formicidae

Leaf-cutter ants live in Central and South America. They can make vast underground nests, where they cultivate a special fungus on chewed leaf fragments as food.

WOOL CARDER BEE
Anthidium manicatum
F: Megachilidae

This European bee makes nests in existing holes in wood or masonry, which it lines with hairs that it collects from certain plants.

SWEAT BEE
Halictus quadricinctus
F: Halictidae

This solitary bee is found across southern Europe and the Mediterranean. It makes large clusters of cells underground in which to rear its young.

ARMY ANT
Eciton burchellii
F: Formicidae

This South American ant forms large colonies of up to two million individuals and attacks large prey.

RIBBON WORMS

Marine worms of the phylum Nemertea are voracious predators, seizing their prey with a proboscis and swallowing it whole or sucking its fluids.

PHYLUM	NEMERTEA
CLASSES	2
ORDERS	3
FAMILIES	41
SPECIES	About 1,150

Ribbon worms are soft, slimy animals, cylindrical in shape or somewhat flattened. Many move by gliding, but some can also swim. One species, *Lineus longissimus*—the bootlace worm—has been recorded growing to 100 ft (30 m) in length. Like others, it has a fragile body that is easily broken.

The proboscis of a ribbon worm is not part of its gut, but emerges from a sac on its head just above the mouth. In some species the proboscis has sharp spikes for gripping or piercing prey, and even venom for immobilizing it. These well-armed species prey on other invertebrates, such as crustaceans, bristle worms, and mollusks. Other ribbon worms feed on dead material.

10–12 in
25–30 cm

PACIFIC STRIPED RIBBON WORM
Baseodiscus hemprichii
F: Valenciniidae

This colorful ribbon worm lives on reefs of the Indo-Pacific. It hunts for invertebrate prey on the bottom of the sea.

3–4 in
8–10 cm

RED RIBBON WORM
Nipponnemertes pulchra
F: Cratenemertidae

Found in cold ocean waters around the world, this shield-headed ribbon worm varies in color from orange to pink or red.

COMMON ATLANTIC RIBBON WORM
Tubulanus annulatus
F: Tubulanidae

A large ribbon worm, this species lives in muddy sediment in intertidal or offshore waters of the Northeast Atlantic and Mediterranean.

4¾–30 in
12–75 cm

BRYOZOANS

These minute animals form coral-like colonies, filter-feeding with microscopic tentacles and, in turn, providing food for grazing invertebrates.

PHYLUM	BRYOZOA
CLASSES	3
ORDERS	4
FAMILIES	About 160
SPECIES	About 4,150

Many bryozoans resemble coral, but are more advanced animals than cnidarians. A colony—genetically a single individual—is made up of thousands of tiny bodies called zooids, each consisting of a retractable fan of tentacles surrounding the mouth. Microscopic, beating hairs on the tentacles waft particles of food down to the mouth, which leads into a U-shaped gut. Waste exits via the anus in the body wall. Although a hand lens is needed to see individual zooids, colonies assume a variety of forms, depending on species. Some are encrustations on rock or seaweed, others grow into bristly thickets or fleshy lobes. Many are heavily calcified like stony corals; others are soft.

FALSE CORAL BRYOZOAN
Myriapora truncata
F: Myriaporidae

A distinctive bryozoan of the Mediterranean, the colonies of this species consist of thick cylinders that branch repeatedly.

1⅛–1¼ in
3–4 cm

4–8 in/10–20 cm

HORNWRACK
Flustra foliacea
F: Flustridae

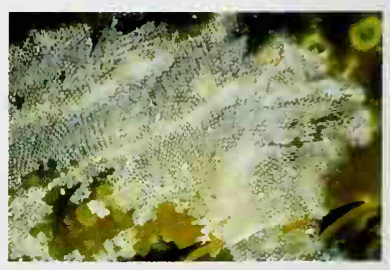
Typical of its family, this bryozoan forms erect leafy colonies. This stiff bushy offshore species is common on rocky northern European coasts.

6–8 in
15–20 cm

PINK LACE BRYOZOAN
Iodictyum phoeniceum
F: Phidoloporidae

Lace bryozoans—sometimes inaccurately called "lace corals"—form tall, rigid colonies. This colorful species lives on coastlines around southern and eastern Australia.

2–8 in/5–20 cm



LACY CRUST BRYOZOAN
Membranipora membranacea
F: Membraniporidae

The bryozoans known as sea mats grow in encrusting lacy sheets. This species forms fast-growing colonies on kelp fronds of the Northeast Atlantic.

LAMPSHELLS

Lampshells look very like bivalve mollusks, but feed instead with tentacles. They belong to a different, very ancient phylum.

PHYLUM	BRACHIOPODA
CLASSES	2
ORDERS	5
FAMILIES	About 25
SPECIES	About 300

The soft bodies of lampshells are enclosed within a two-valved shell, one valve larger than the other. The shell is either attached to the seabed with a rubbery stalk or is directly cemented to rock. The shell valves are positioned top-and-bottom around the animal—not around the sides, as in bivalve mollusks. Like mollusks, lampshells have a fleshy mantle attached to the inner surface of the shell, which encloses a mantle cavity. In the mantle cavity there is a ring of tentacles with microscopic beating hairs that drive particles to a central mouth—just like the feeding structure in bryozoans.

The fossil record shows that lampshells were much more common and demonstrated much greater diversity in the warm, shallow seas of the Palaeozoic Era. They began to decline dramatically during the time of the dinosaurs—perhaps because bivalve mollusks were more successful.

¾–1¾ in
2–3 cm

EUROPEAN LAMPSHELL
Terebratulina retusa
F: Cancellothyrididae

Found from the Northeast Atlantic to the Mediterranean, this lampshell has pear-shaped valves and attaches to vertical rocks with a short stalk.

1¾–2¼ in
3–5.5 cm

hinged, two-valved shell

PACIFIC LAMPSHELL
Terebratalia transversa
F: Terebratalidae

An abundant lampshell of the Northern Pacific, this short-stalked species has a variable smooth or ribbed shell.

⅜–⅝ in
1–1.5 cm

INARTICULATED LAMP SHELL
Neocrania anomala
F: Craniidae

A brachiopod of North Atlantic waters, this species cements its shell to rock, and superficially resembles a limpet.

MOLLUSKS »

Mollusks are a large, highly diverse group, ranging from blind filter-feeding bivalves cemented to rock, through voraciously grazing snails and slugs, to lively, intelligent octopus and squid.

PHYLUM	MOLLUSCA
CLASSES	7
ORDERS	46
FAMILIES	609
SPECIES	About 110,000

A typical mollusk has a soft body carried on a large muscular foot, and a head that senses the world using eyes and tentacles. The internal organs (viscera) are contained in a visceral hump, which is covered by a fleshy mantle. This mantle overhangs the edge of the hump, creating a groove called the mantle cavity, which is used for breathing. In most species, this mantle also secretes substances used to make the shell. Most mollusks feed with a tongue called a radula. Coated in teeth made of chitin, the radula moves forward and backward through the mouth to rasp at food. Bivalves lack a radula. They feed instead by siphoning particles through their shells. Most species trap particles of food in the mucus on their gills.

These limpets have grazed the rock around them bare, but they cannot reach the green algae growing on top of their own shells.

WITH AND WITHOUT SHELLS

A shell is not only a refuge from predators, it is also protection from drying out. Some snails even have a trapdoor called an operculum to seal the opening of the shell. The shell is hardened with minerals obtained from the diet and surrounding water. It is coated in tough protein; and smooth on the inside, to allow the body to slide in and out—some groups have a lining of mother-of-pearl. Many shell-less mollusks defend themselves with distasteful or poisonous chemicals, and advertise this with striking colors.

Most cephalopods—tentacled mollusks, such as octopus and squid—lack an obvious shell. Members of this group are entirely predatory and have a horny beak for chewing on flesh. Their muscular foot is modified into their characteristic tentacles, which are used for grasping and swimming.

GETTING OXYGEN

Most mollusks are aquatic and so they have gills for breathing, usually projecting into the mantle cavity and irrigated by a current of water. In most land snails and slugs the mantle cavity is filled with air and functions as a lung. Because many freshwater snails probably evolved from this group, they have a lung too, and must frequently surface to breathe.

APLACOPHORANS

More wormlike than mollusklike, the Aplacophora are small cylindrical burrowers that feed on detritus or other invertebrates in the sediment of deep oceans. They lack a shell, but their clearly molluskan features include a rasping, tonguelike radula. The mantle cavity is reduced to an opening at the rear of the body, into which the animal discharges waste from the gut.

⅛–3½ in
0.3–8 cm

COMMON GLISTENWORM
Chaetoderma sp.
F: Chaetodermatidae

A typical member of its class, this wormlike mollusk of the North Atlantic burrows through muddy sediment of ocean depths.

BIVALVES

Highly specialized aquatic mollusks, bivalves are instantly recognizable, with hinged shells that open up to access food and oxygen-rich water.

Bivalves are identifed from their shells, which consist of two plates, called valves, joined together by a hinge. To protect against predators and the dangers of drying out, the shells clamp tightly shut by contracting powerful muscles, sealing most or all of the body inside. Seashore species are regularly exposed by receding tides.

Within the class there is a huge variation in size, ranging from the tiny fingernail clam at about ¼ in (6 mm) to the giant clam, which can grow to 4½ ft (1.4 m) across. Some bivalves attach to rocks and hard surfaces by a bundle of tough threads, called a byssus. Others use a well-developed muscular foot for burrowing into muddy sediment. A few bivalves, such as scallops, swim freely, using a method of jet propulsion.

Water is pumped in and out of bivalve shells through tubes, called siphons. The water supplies oxygen and food, which are collected as the water passes over modified gills. Food particles caught in the sticky mucus around the gills is wafted toward the mouth by microscopic hairs.

BIVALVES AND PEOPLE

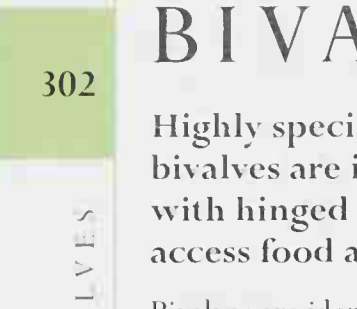
Mussels, clams, and oysters are important sources of food, and some oysters create fine quality pearls by coating a foreign object with layers of nacre. Bivalves are also useful indicators of water quality as many cannot survive high levels of pollution.

PHYLUM	MOLLUSCA
CLASS	BIVALVIA
ORDERS	10
FAMILIES	105
SPECIES	About 8,000

A queen scallop claps the two valves of its shell together to accelerate away from the unwelcome attention of a predatory starfish.

OYSTERS AND SCALLOPS

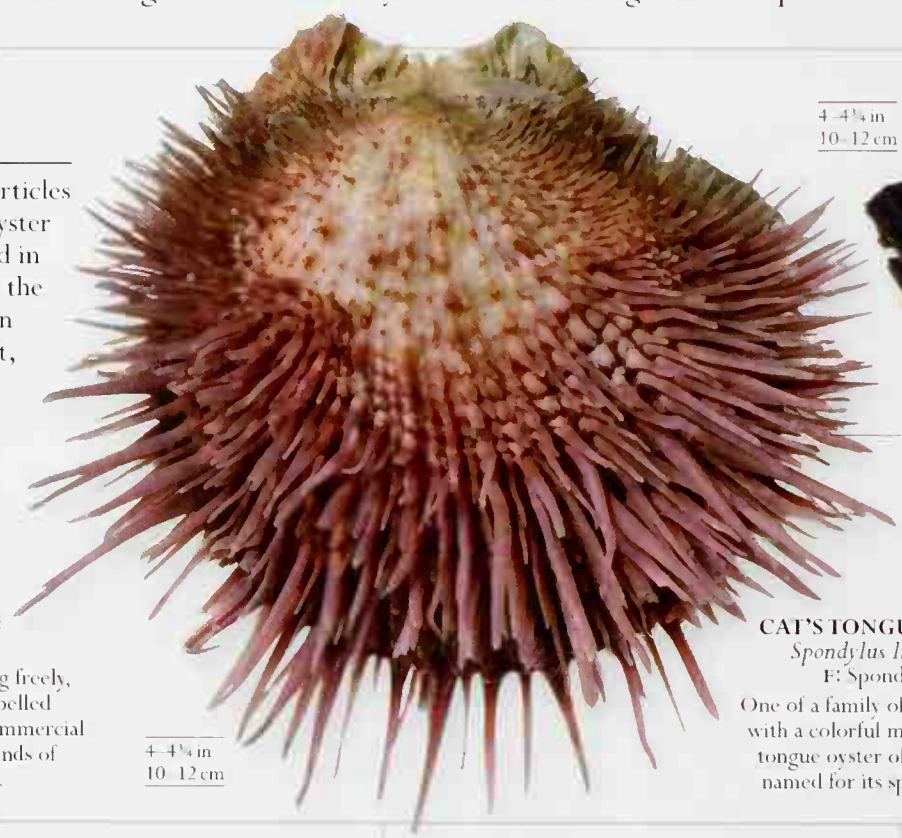
The Ostreoida feed on tiny food particles filtered from the seawater. Many oyster species live permanently submerged in coastal waters, fixed to the rock by the gland that produces byssus thread in other bivalves. Scallops, by contrast, can swim freely by clapping their valves open and shut.



4¾–6 in
12–15 cm

GREAT SCALLOP
Pecten maximus
F: Pectinidae

In addition to swimming freely, scallops have jet-propelled escape responses. This commercial species inhabits fine sands of European coasts.



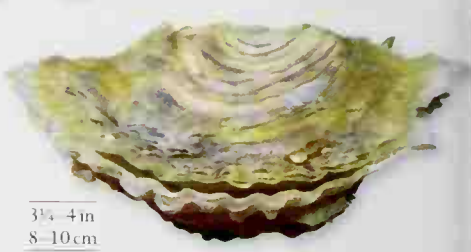
4–4¾ in
10–12 cm

spiny left valve

4–4¾ in
10–12 cm

COCK'S COMB OYSTER
Lopha cristagalli
F: Ostreidae

Close relatives of scallops, many species of oysters are prized as food and for their pearls. This is an Indo-Pacific species.



3¼–4 in
8–10 cm

EDIBLE OYSTER
Ostrea edulis
F: Ostreidae

Formerly abundant in Europe, this commercially important species is now over-fished in some areas. The species is inedible during summer months when breeding.

CAT'S TONGUE OYSTER
Spondylus linguafelis
F: Spondylidae

One of a family of thorny oysters with a colorful mantle, the cat's tongue oyster of the Pacific is named for its spiny exterior.

ARC CLAMS AND RELATIVES

Shells of these bivalves are closed by two strong muscles, and hinge along a straight line bearing a continuous series of teeth. Like their relatives, the Arcoida have a reduced foot and large gills that help trap food particles.

2–2¾ in
5–7 cm

NOAH'S ARK
Arca noae
F: Arcidae

Arc shells are square-edged, thick-shelled bivalves. Noah's Ark is a byssus-attached intertidal species on rocky coasts of the eastern Atlantic.

2–2¼ in
5–6 cm

EUROPEAN BITTERSWEET
Glycymeris glycymeris
F: Glycymeridae

Dog shells are rounded relatives of arc shells. This Northeast Atlantic species, fished in Europe, has a sweet flavor but is tough when overcooked.

MARINE MUSSELS

The Mytiloida have distinctively shaped elongate, asymmetrical shells that attach to rocks by byssus threads. Only one of their two shell-closing muscles is well developed.

3¼–4 in
8–10 cm

COMMON MUSSEL
Mytilus edulis
F: Mytilidae

The most commercially important mussel in Europe, this long-lived species occurs in dense beds. It can tolerate the low salinity of estuarine waters.

FAN MUSSELS AND RELATIVES

Members of the Pterioida include long-hinged, winged oysters and T-shaped hammer-oysters as well as fan mussels. The group also contains commercially important marine pearl oysters.

10–16 in
25–40 cm

FLAG FAN MUSSEL
Atrina rexillum
F: Pinnidae

Fan mussels, such as this species from western European coastlines, have triangular shells attached by a byssus in soft sediment.

FRESHWATER MUSSELS

The Unionoida are the only exclusively freshwater order of bivalves. The tiny larvae use their valves to clamp onto fish, forming cysts on the gill fins and feeding on blood or mucus before dropping off as juvenile mussels.

4–6 in
10–15 cm

3½–4 in
9–10 cm

SWAN MUSSEL
Anodonta sp.
F: Unionidae
Batterling fish lay eggs in living freshwater mussels, such as this Eurasian species. The mollusk becomes a nursery for fish fry.

FRESHWATER PEARL MUSSEL
Margaritifera margaritifera
F: Margaritiferidae
Well known for its good-quality pearls, this mussel lives buried in sand or gravel beneath fast-flowing rivers in Eurasia and N. America.

TRUE CLAMS AND BORING BIVALVES

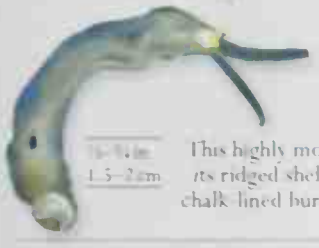
Long-siphoned bivalves in the order Myoida typically burrow in mud or bore through wood or rock. In piddocks the front of the shell acts like a file to bore burrows in soft rock. Shipworms use their shell valves to drill through timber.

4¾–6 in/12–15 cm

COMMON PIDDOCK
Pholas dactylus
F: Pholadidae
This common piddock of the northeastern Atlantic is phosphorescent and, like other species, lives in burrows bored in wood or clay.

4¾–6 in
12–15 cm

SOFT SHELL CLAM
Mya arenaria
F: Myidae
An edible clam with a thin shell, this North Atlantic species is especially abundant in muddy estuaries, where it burrows in soft sediment.



½–¾ in
1.5–2 cm

SHIPWORM
Teredo navalis
F: Teredinidae
This highly modified, widespread bivalve uses its ridged shell valves as a drill to bore deep, chalk-lined burrows in timber, damaging ships.

WATERING POTS AND RELATIVES

The order Pholadomyoida includes clams and tropical watering pots. Scarcely recognizable as bivalves, watering pots live encased in chalky tubes, and draw detritus and water into the tube through a perforated plate at the anterior end.

6–6½ in
15–17 cm

PHILIPPINE WATERING POT
Penicillus philippinensis
F: Clavagellidae
This bizarre Indo-Pacific watering pot belongs to a family named for their wide, perforated ends, fringed with tubules. It lives partially buried in sediment.

COCKLES AND RELATIVES

The largest order of bivalves, the Veneroida include a large range of marine animals. Most have short siphons that are often fused together. Some, notably the cockles, are agile, capable of burrowing or even leaping with their foot. Others are attached to rocks by a byssus.

1¾–1¾ in
3–4 cm

ZEBRA MUSSEL
Dreissena polymorpha
F: Bivalvia
This freshwater mussel is anchored by byssus threads, but can detach and crawl on a slender foot. Native to eastern European waters, it has spread elsewhere.

COMMON EDIBLE COCKLE
Cerastoderma edule
F: Cardiidae
Sand-burrowing cockles have shells with radiating ribs. This northeastern Atlantic species, often found in vast numbers, is fished in northern Europe.

1½–2 in
4–5 cm

6–8 in
15–20 cm

SWORD RAZOR CLAM
Ensis siliqua
F: Pharidae
Razor shells, such as this northeast Atlantic species, live in burrows, feeding and respiring through their emergent siphon, but drop quickly using their muscular foot when disturbed.

1–1¼ in
2.5–3 cm

concentric rings

ROYAL COMB VENUS
Pitar dione
F: Veneridae
Named for the comb-like spines on its shell, this Venus clam occurs on tropical American coastlines.

2–3½ in
5–8 cm

RED CALLISTA
Callista erycina
F: Veneridae
Many Venus clams are prized by collectors, including this Indo-Pacific species, also known as the sunset clam.

RINGED DOSINIA
Dosinia anus
F: Veneridae
This Venus clam is found on the coastlines of New Zealand, and is one of many species harvested for human consumption.

algae within mantle exposed to sunlight

3½–4½ in/1–1.4 m

GIANT CLAM
Tridacna gigas
F: Cardiidae
The world's largest bivalve, this long-lived and now endangered coral-dwelling animal lives on sandy beds in the Indo-Pacific.

2–2½ cm
5–7 cm

SUNRISE TELLIN
Tellina radiata
F: Tellinidae
The shell of this tellin from the Caribbean has a variable banding pattern and is often found on beaches.

3½–3¾ in
8–9 cm

WEST AFRICAN TELLIN
Tellina madagascariensis
F: Tellinidae
Tellins, such as this rose-colored tropical species, feed on particles in sediment, drawn in through their long, extendable siphons.

STRIPED TELLIN
Tellina virgata
F: Tellinidae
The shells of many tellins, such as this Indo-Pacific species, have decorative patterns.

1¼–1½ in
3–4 cm

2½–3½ cm
6–8 cm

large, scale-like flutes

12–16 in
30–40 cm

FLUTED GIANT CLAM
Tridacna squamosa
F: Cardiidae
Like other Indo-Pacific giant clams, this species opens its shell during the day so that algae in its colored mantle can photosynthesize to make food.

GASTROPODS

Gastropods are by far the largest class of mollusks. The word gastropod means "stomach-foot," because the animal appears to crawl on its belly.

Most snails and slugs glide along a stream of slime on a single muscular foot, rasping at their food with a radula, a tonguelike emery board. Most gastropods use their radula to rasp at vegetation, algae, or the fine film of microbes that coat underwater rocks, but some are predatory. They usually have a distinct head with well-developed sensory tentacles. Snails have a coiled or helical shell into which they can withdraw; slugs lost their shells during the course of evolution. The class also includes a number of animals that deviate from this basic plan, such as swimming sea slugs. Gastropods originated in the oceans and they still have their greatest diversity there; other species live in fresh water or on land.

TORSION

The juvenile gastropod undergoes a process called torsion: the whole of the body within the shell twists round 180 degrees, so that the respiratory mantle cavity comes to lie above the animal's head. This allows the vulnerable head to withdraw into the safety of the shell. In marine snails, such as periwinkles and limpets, this body form persists into adulthood. Because of this, marine snails are described as prosobranchs, meaning "forward gills". In sea slugs, however, the body twists back again, and they are called opisthobranchs, or "hind gills".

PHYLUM	MOLLUSCA
CLASS	GASTROPODA
ORDERS	21
FAMILIES	409
SPECIES	About 90,000

DEBATE

A COMMON TWIST

Sea snails were originally grouped together because their bodies twist during development so that their gills face forward. But the ancestor of all snails probably had this feature, and now marine snails are split into groups based on other characteristics. Their exact relationships remain debatable.

TRUE LIMPETS

Primitive algae-grazing limpets, the Patellogastropoda have a slightly coiled, conical shell. Their powerful muscles clamp down firmly on intertidal rocks, protecting them from predators, desiccation, and waves.

1¼–2 in
3–5 cm

COMMON LIMPET
Patella vulgata
F: Patellidae

This species grazes algae from rocks on shores of the Northeast Atlantic at high tide, then returns to a depression in the rock that matches the shape of its shell.

NERITES AND RELATIVES

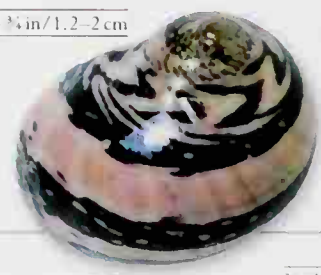
A small but diverse group, Cycloneritimorpha are well known in the fossil record. They include marine, freshwater, and land-living forms, some with coiled shells, and a few like limpets. There are also species with trapdoors to their shells.

¾–2 in
2–5 cm

BLEEDING TOOTH NERITE
Nerita peloronta
F: Neritidae

Named for the blood-red mark on its shell opening, this Caribbean intertidal mollusk can survive out of water for prolonged periods.

½–¾ in/1.2–2 cm



ZIGZAG NERITE
Neritina communis
F: Neritidae

An inhabitant of Indo-Pacific mangroves, this is a highly variable species, with white, black, red, or yellow shells even in the same population.

TOP SHELLS AND RELATIVES

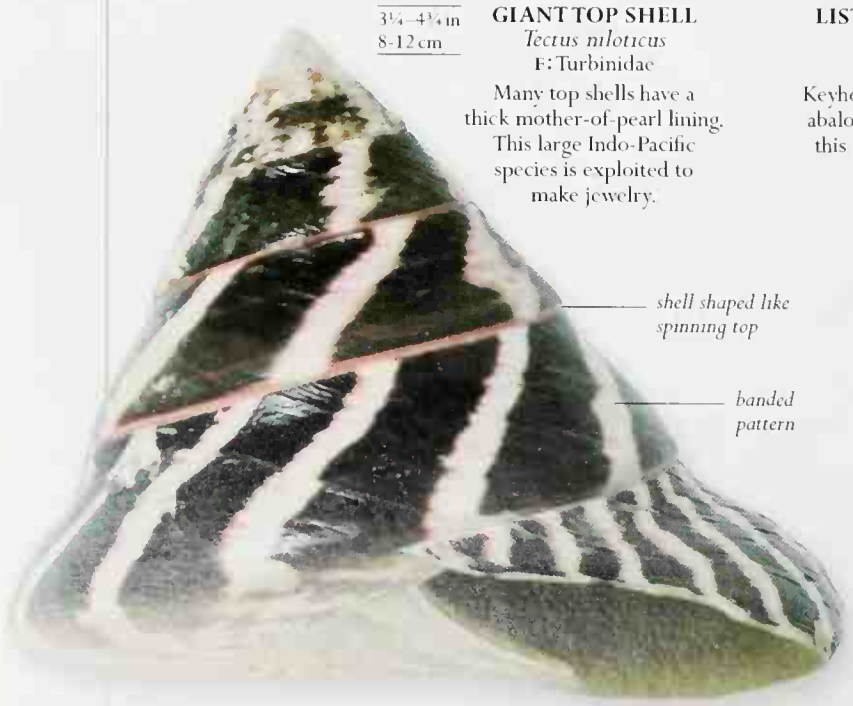
The Vetigastropoda are marine gastropods that graze algae and microbes with a brushlike radula. Their shells range from those of keyhole limpets, with the barest suggestion of a spire, to the coiled globes and pyramids of top shells, which can seal themselves inside using an operculum, or trapdoor.

¾–1 in
2–2.5 cm

CHECKERED TOP SHELL
Osilinus turbinatus
F: Trochidae

Top shells have "spinning-top" shells that are closed with a circular operculum. This is a Mediterranean species.

3¼–4¾ in
8–12 cm



GIANT TOP SHELL
Tectus niloticus
F: Turbinidae

Many top shells have a thick mother-of-pearl lining. This large Indo-Pacific species is exploited to make jewelry.

LISTER'S KEYHOLE LIMPET
Diodora listeri
F: Fissurellidae

Keyhole limpets are close relatives of abalones and top shells. Like others, this western Atlantic species ejects oxygen-depleted water through its "keyhole."

½–1¾ in
1.5–4.5 cm

2–2¾ in/5–7 cm

SILVER MOUTH TURBAN SHELL
Turbo argyrostomus
F: Turbinidae

Turban shells are close relatives of top shells, but have a calcified operculum. This is an Indo-Pacific species.

8–12 in
20–30 cm

RED ABALONE
Haliotis rufescens
F: Haliotidae

Abalones have ear-shaped shells lined with thick mother-of-pearl and punctuated with holes for exhaling water. This Northeast Pacific kelp-grazing species is the largest.

TOWER SHELLS AND RELATIVES

These tall-spired snails typically live in muddy or sandy sediment. They feed on particles in the water that they circulate through their mantle cavity. The Cerithioidea are found in marine, freshwater, and estuarine habitats. They are slow moving and often group together in very large numbers.

1–2¾ in
2.5–5.5 cm

GREAT SCREW SHELL
Turritella terebra
F: Turritellidae

A filter feeder of muddy sediments, this Indo-Pacific snail belongs to a group variously known as tower shells or auger shells.

ROUGH CERITH
Rhinoclavis asper
F: Cerithidae

Ceriths are snails often abundant in shallow-water tropical marine sediments. Like others, this Indo-Pacific species lays strings of eggs attached to solid material.

2½–7 in
6–17 cm

WEST INDIAN WORM SHELL
Vermicularia spirata
F: Turritellidae

Free-floating males of this Caribbean unwound screw shell attach to solid material, often embedding themselves in sponges. They then develop into larger sedentary females.

2.5–16 cm
1–6¼ in

PERIWINKLES, WHELKS, AND RELATIVES

The largest and most diverse order of marine snails, the Caenogastropoda are divided into three groups. Ptenoglossids—wentletraps and violet snails—are free-floating or swimming specialist predators of cnidarians. Littorinids graze on algae, and include periwinkles, cowries, and conches. Whelks and their relatives are predators that project a long siphon out through a groove in the shell.

1–2¾ in
2.5–7 cm

PRECIOUS WENTLETRAP
Epitonium scalare
F: Epitoniidae

Wentletraps (from the German for spiral staircase) prey on anemones and corals and have cutting jaws. This is an Indo-Pacific species.

¾–1 in
2–4 cm

LARGE VIOLET SNAIL
Janthina janthina
F: Janthinidae

Violet snails float on tropical oceans, preying on floating cnidarians. They secrete mucus to create rafts of bubbles that keep them buoyed up.

4–6 in
10–15 cm

TIGER COWRIE
Cypraea tigris
F: Cypraeidae

The fleshy lobes of a cowrie's mantle wrap right around the smooth shell when it crawls. This Indo-Pacific species preys on other invertebrates.

spikes help attach objects

SUNBURST CARRIER
Stellaria solaris
F: Xenophoridae

Carrier snails cement objects such as pebbles or shells of other animals to their shells for camouflage. This species inhabits Indo-Pacific waters.

2½–5 in
6–13 cm

¾–2¼ in
1.5–6 cm

FOOL'S CAP
Capulus ungaricus
F: Capulidae

This North Atlantic gastropod resembles unrelated limpets, attaching itself to stones or even shells of other mollusks, such as scallops.

attached detritus

ATLANTIC SLIPPER LIMPET
Crepidula fornicata
F: Calyptraeidae

Unrelated to true limpets, filter-feeding slipper limpets form mating towers, with smaller males on top changing sex to replace dead females beneath.

¾–2 in
2–5 cm

COMMON PELICAN'S FOOT
Aporrhais pespelecani
F: Aporrhaidae

Cousins of conches, pelican's foot snails are mud-dwelling detritus eaters with extensions to their shells that look like webbed feet. This species inhabits the Mediterranean and the North Sea.

12–16½ in / 30–42 cm

¾–1¼ in
2–3 cm

COMMON PERIWINKLE
Littorina littorea
F: Littorinidae

Periwinkles, such as this European species, form a family of intertidal snails with a globular spired shell closed by an operculum.

6–12 in
15–31 cm

PINK CONCH
Strombus gigas
F: Strombidae

Conches are mostly tropical, medium to large marine grazing snails. *Strombus* conches, such as this giant West Atlantic species, have flare-lipped shells.

»

» PERIWINKLES, WHELKS, AND RELATIVES

4–12½ in
10–32 cm

GIANT FROG SHELL
Tutufa bubo
F: Bursidae

Tropical marine frog shells are warty. This Indo-Pacific species eats bristleworms using a proboscis, first anesthetizing them with saliva.

4–20 in
10–50 cm

TRUMPET TRITON
Charonia tritonis
F: Ranellidae

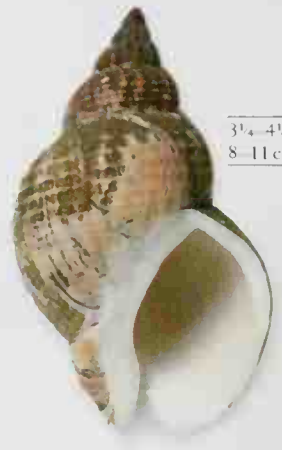
Tropical intertidal tritons and related frog and helmet shells are predators of other invertebrates. This Indo-Pacific species eats the aggressive crown of thorns starfish.

3/16–1¼ in
0.5–3 cm

POLI'S NECKLACE SHELL
Euspira pulchella
F: Naticidae

This is a European member of a family of sand-burrowing predators of bivalves. Necklace shells are named for their necklacelike ribbons of spawn.

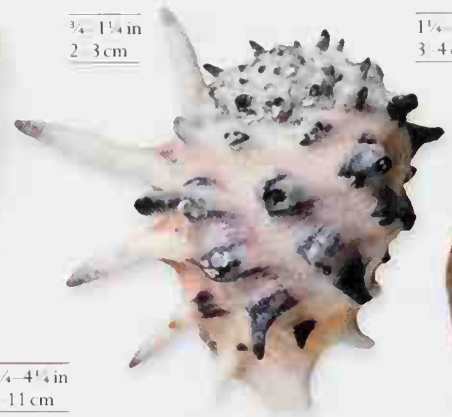
3¼–4¼ in
8–11 cm



COMMON NORTHERN WHELK
Buccinum undatum
F: Buccinidae

A large predator of other mollusks and tube worms, this North Atlantic snail also consumes carrion, and is a popular seafood.

¾–1¼ in
2–3 cm



PRICKLY PACIFIC DRUPE
Drupa ricinus
F: Muricidae

A member of the dog whelk family, this snail lives on coral reefs of the Indo-Pacific, where it preys on bristle worms.

1¼–1½ in
3–4 cm

DOG WHELK
Nucella lapillus
F: Muricidae

This North Atlantic snail belongs to a whelk family that catch prey by using the radula to drill holes in the shells of barnacles and mollusks, helped by secretions of enzymes.

3½–6 in
9–15 cm

TEXTILE CONE
Conus textile
F: Conidae

Cone shells use their radula to harpoon their prey and inject venom. Some, such as this Indo-Pacific species, can be harmful to humans.

1⅛–5 in
3–13 cm

TENT OLIVE
Oliva porphyria
F: Olividae

The largest of the olive snails, this species from the Pacific coasts of Mexico and South America has a colorful glossy shell.

3–4½ in
7.5–11.5 cm

BANDED TULIP
Cinctura lilium
F: Fasciolariidae

This is a Caribbean coral-dwelling snail related to *Buccinum* whelks. Sand-dwelling species with longer siphonal canals are called spindle shells.

2¼–4¼ in
6–11 cm

IMPERIAL HARP
Harpa costata
F: Harpidae

Harp snails are sand-living predators of crabs, trapping them with their broad foot and digesting them with saliva. This is an Indian Ocean species.

2¾–8 in
7–20 cm

SUBULATE AUGER
Terebra subulata
F: Terebridae

Typical of many augers, this Indo-Pacific species has a patterned shell. Augers burrow through surface layers of sand to prey on worms.

FRESHWATER GILLED SNAILS

The Architaenioglossa are the only order of gilled snails containing no marine species. Most live in freshwater, but some live on land. Apple snails have gills in the mantle cavity that can function as a lung, allowing them to survive periods of drought. All species have an operculum for closing their shells.

4–6 in
10–15 cm

CHANNELED APPLE SNAIL
Pomacea canaliculata
F: Ampullariidae

A typical apple snail, this tropical American species has been introduced elsewhere and has become an invasive pest.

COMMON RIVER SNAIL
Viviparus viviparus
F: Viviparidae

A European freshwater snail with gills, this is a relative of the apple snails and, like them, has a trapdoor (operculum) to close its shell.

1¼–1½ in/3–4 cm

SEA HARES

Sensory water-tasting head stalks, a common feature of sea slugs, are so big in the large sea hares that they resemble ears. The Anaspidea have a small internal shell and, like sea angels, can swim with their foot flaps.

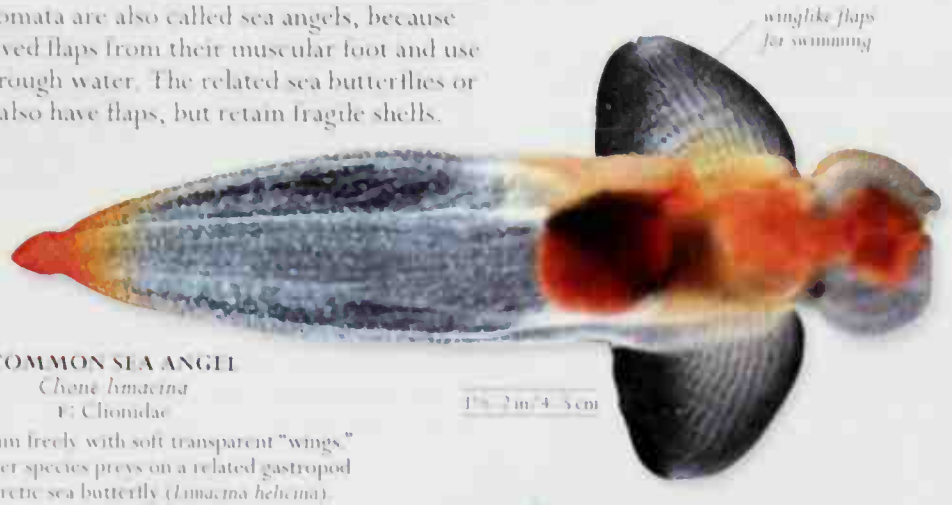
2¾–8 in
7–20 cm

SPOTTED SEA HARE
Aplysia punctata
F: Aplysiidae

Like other seaweed-eating sea hares, this European species gathers in large breeding groups. As a defense, it releases ink when disturbed by predators.

SWIMMING SEA SLUGS

The Gymnosomata are also called sea angels, because they have evolved flaps from their muscular foot and use them to fly through water. The related sea butterflies or Thecosomata also have flaps, but retain fragile shells.



1¾–2 in/4–5 cm

COMMON SEA ANGEL
Clione limacina
F: Clionidae

Sea angels swim freely with soft transparent "wings." This cold-water species preys on a related gastropod called the Arctic sea butterfly (*Limacina helicina*).

TRUE SEA SLUGS

The Nudibranchia are the largest group of sea slugs. Nudibranch means "naked gills" and refers to the fact that these animals' gills are exposed on their back, rather than contained in a mantle cavity. Many species have vibrant color patterns to advertise their toxicity.

2–3½ in
5–8 cm

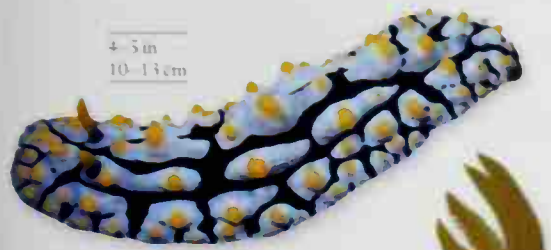
BLACK-MARGINED SEA SLUG
Glossodoris atromarginata
F: Chromodorididae

This common Indo-Pacific sea slug lives in shallow waters, feeding on sponges. It varies in color from off-white to pale yellow.

1½–2 in
4–5 cm

OPALESCENT SEA SLUG
Hermissenda crassicornis
F: Facelinidae

This intertidal northern Pacific species belongs to a group of sea slugs with body outgrowths that store the still potent stinging organs of their jellyfish prey.



4–5 in
10–13 cm

VARICOSE SEA SLUG
Phyllidia varicosa
F: Phyllidiidae

This Indo-Pacific sea slug is a common inhabitant of rocks, rubble, and sand in coastal waters, where it preys on sponges.

¾–2 in
2–5 cm

ANNA'S SEA SLUG
Chromodoris annae
F: Chromodorididae

Like other *Chromodoris* sea slugs, this variable species from the western Pacific Ocean specializes in feeding on sponges.

2¼–3¼ in
7–8 cm

ELEGANT SEA SLUG
Okenia elegans
F: Goniodorididae

Typical of its family, this sea slug feeds on sea squirts. It occurs in waters around Europe, including the Mediterranean.

4–4½ in/10–12 cm

VARIABLE NEON SEA SLUG
Nembrotha kubaryana
F: Polyceridae

This Indo-Pacific sea slug preys on sea squirts and incorporates their defensive chemicals into its mucus. Many of its relatives prey on bryozoans.

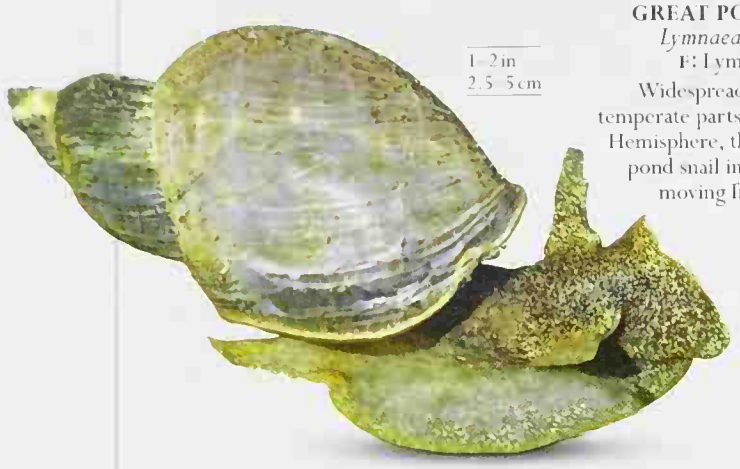
15–16 in/38–40 cm

SPANISH DANCER
Hexabranchus sanguineus
F: Chromodorididae

A giant Indo-Pacific sea slug, this species gets its name from its free-swimming movements; its red mantle is said to resemble the ruffled skirt of a flamenco dancer.

FRESHWATER AIR-BREATHING SNAILS

Snails of the order Basommatophora have their mantle cavity developed as a lung; unlike most other marine gastropods, they must return to the water surface to breathe. Mainly herbivorous, they are common in alkaline or neutral, weed-choked, stagnant or slow-moving freshwater.



1–2 in
2.5–5 cm

GREAT POND SNAIL
Lymnaea stagnalis
F: Lymnaeidae

Widespread throughout temperate parts of the Northern Hemisphere, this is a common pond snail in still or slow-moving freshwater.

3/8–5/8 in
1–1.6 cm

EUROPEAN BLADDER SNAIL
Physella acuta
F: Physidae

Most snails have shells that open to the right (when the opening faces the observer), but the freshwater physid family have left-opening shells.

3/16–5/16 in
5–8 mm

COMMON RIVER LIMPET
Ancylus fluviatilis
F: Planorbidae

Not a true limpet, but a limpetlike member of the ramshorn snail family, this species is common in fast-flowing European waters.

1¼–1½ in
3–3.5 cm

GREAT RAMSHORN SNAIL
Planorbarius corneus
F: Planorbidae

Ramshorn snails have flat-coiled shells, instead of the spire shells typical of snails. Most—like this Eurasian species—occur in still freshwater.

LAND AIR-BREATHING SNAILS AND SLUGS

The Stylommatophora are land snails and slugs that breathe air using a lung in their mantle cavity. They have eyes at the tips of their tentacles. Many are hermaphrodite and have both male and female reproductive organs. Their courtship behavior involves the exchange of spearlike darts before mating.

1–1¾ in
2.5–4.5 cm

BROWN GARDEN SNAIL
Helix aspersa
F: Helicidae

This variably colored species with a wrinkled shell is widespread in European woods, hedgerows, dunes, and gardens.

1¾–2 in
3–5 cm

ROMAN SNAIL
Helix pomatia
F: Helicidae

Widespread in central Europe on calcium-rich soils, this is the largest snail of the region and is bred locally for human consumption.

6–9 in
15–22 cm

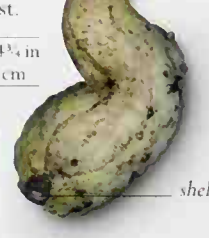
GIANT AFRICAN SNAIL
Achatina fulica
F: Achatinidae

This giant land snail from East Africa has been introduced to many other warm parts of the world, becoming an invasive pest.

1¼–1½ in
3–3.5 cm

CUBAN LAND SNAIL
Polymita picta
F: Cepolidae

This snail is only found in the mountain forests of Cuba. Its shells, which exist in numerous colors, are prized by collectors.



3¾–4¾ in
8–12 cm

¼ in / 7–8 mm

4–8 in
10–20 cm

EUROPEAN BLACK SLUG
Arion ater
F: Arionidae

Black specimens of this European slug predominate in the north, but other individuals are orange. Although it eats plants, it also clears garden waste.

6–10 in / 15–25 cm

PACIFIC BANANA SLUG
Ariolimax columbianus
F: Ariolimacidae

Named for its yellow color, the Pacific banana slug lives in wet coniferous forests on the western coast of North America.

¾–1¼ in
2–3 cm

BROWN-LIPPED SNAIL
Cepaea nemoralis
F: Helicidae

A close relative of the Roman snail, this western European species has a highly variable shell color, and banding patterns for camouflage in different habitats.

4–12 in
10–30 cm

ASHY-GREY SLUG
Limax cinereoniger
F: Limacidae

Keel-back slugs have a small internal shell. This large species of European woodland exists in a number of color varieties.

CEPHALOPODS

Cephalopods are agile hunters in the mollusk phylum. Their sophisticated nervous system enables them to hunt down fast-moving prey.

Cephalopods include the most intelligent of all invertebrates. Many species signal their mood using pigment-containing structures in their skin called chromatophores. The class is organized by number of arms. Squid and cuttlefish have eight arms used for swimming, plus two longer retractable arms, called tentacles, with suckers for gripping prey. Octopus lack tentacles, but have suckers on all eight of their arms. The cephalopod mantle encloses a cavity, which contains the gills. To obtain oxygen, cephalopods take in water through the sides of the mantle. It passes over the gills and is then expelled through a short funnel. Cephalopods can move backward quickly by expelling water through the funnel, to propel themselves forwards. Squid, cuttlefish, and some octopus have fins on the sides of the mantle, used for open-water swimming. Most octopus spend their time on the sea floor.

Only the open-ocean nautilus has a coiled shell. In squid the shell is reduced to a pen-like structure that gives some internal support, in cuttlefish to a similar, calcified structure called a cuttlebone. Most species of octopus have lost their shell.

Cephalopods are fast-moving predators that use their arms to grasp prey, and a parrotlike beak to despatch it. Squid catch free-swimming prey, while cuttlefish and octopus take slower, bottom-crawling crustaceans, such as crabs.

PHYLUM	MOLLUSCA
CLASS	CEPHALOPODA
ORDERS	About 8
FAMILIES	About 45
SPECIES	About 750

A North Pacific giant octopus discharges black-pigmented ink in self-defense as it jets away from a predator.

6–9½ in
15–24 cm

CHAMBERED NAUTILUS
Nautilus pompilius
F: Nautilidae

This Indo-Pacific species is the largest and best-known living member of a small group of cephalopods otherwise known only as fossils.

2¼–2¾ in
6–7 cm

tentacles at front

FLAMBOYANT CUTTLEFISH
Metasepia pfefferi
F: Sepiidae

Unusual among cuttlefish for its habit of using its tentacles to walk on ocean floors, this Indo-Pacific cuttlefish has recently been shown to be poisonous.

18–20 in
45–50 cm

BROADCLUB CUTTLEFISH
Sepia latimanus
F: Sepiidae

This large cuttlefish is wide-ranging throughout the Indo-Pacific region. It is an abundant predator on coral reefs, feeding on prawns and shrimps.

16–20 in
40–50 cm

COMMON CUTTLEFISH
Sepia officinalis
F: Sepiidae

Like many other cuttlefish, this species migrates inshore to spawn on muddy sediments. It occurs off the coasts of Europe and South Africa.

18–20 in / 45–50 cm

AUSTRALIAN GIANT CUTTLEFISH
Sepia apama
F: Sepiidae

The largest known cuttlefish, this animal inhabits waters off the southern coast of Australia, living in seagrass beds and rocky reefs.

8–20 in
20–50 cm

prey-snatching tentacle

WHIP-LASH SQUID
Mastigoteuthis sp.
F: Mastigoteuthidae

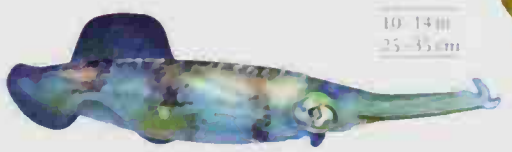
Reddish whip-lash squid such as this species hover with broad fins in deep water, waiting for prey with its long tentacles extended.

¾–1¼ in
2–4 cm

BERRY'S BOBTAIL SQUID
Euprymna berryi
F: Sepiolidae

Bobtail squid, such as this Indo-Pacific species, are small cuttlefish relatives. They have a pen, not cuttlebone, and the rounded body has lobed fins.

10–14 in
25–35 cm



BIGFIN REEF SQUID
Sepioteuthis lessoniana
F: Loliginidae

A pair of large fins makes this Indo-Pacific squid resemble a cuttlefish. It communicates by flashing light from special organs, which contain light-emitting bacteria.

12–18 in
30–45 cm

COMMON SQUID
Loligo vulgaris
F: Loliginidae

This commercially important squid is common in the northeast Atlantic and Mediterranean. Like related species, it has prominent side fins.

1¼–1¾ in
3.5–4.5 cm

RAM'S HORN SQUID
Spirula spirula
F: Spirulidae

This small, deep-ocean cephalopod contains a spiral gas-filled shell that acts as a float, the animal rises toward the ocean surface at night.

»

COMMON OCTOPUS

Octopus vulgaris

Whether it is extricating a lobster from a lobster pot or hunting a scuttling crab, the common octopus is one of the most intelligent of all the invertebrates. This sea-living mollusk has excellent vision and eight grasping arms or tentacles which are also used for crawling. The octopus can change color in an instant, and it can squeeze through very narrow crevices. Its horny beak can bite into prey, whose scattered shell fragments frequently litter the sand around its lair. But in spite of its versatility, the common octopus is short-lived. Upon hatching, an infant octopus enters the oceanic plankton with half a million of its siblings, before descending to the seabed two months later. If it is not eaten, it takes little more than a year to mature and spawn its own offspring before dying. The common octopus is widespread in tropical and warm temperate oceanic waters, and may consist of several similar species.

SIZE Tentacle span 5–9¾ ft (1.5–3 m)
HABITAT Rocky coastal waters
DISTRIBUTION Widespread in tropical and warm temperate waters
DIET Crustaceans, shelled mollusks

fleshy mantle encloses a cavity that contains vital organs, including gills for breathing

> INTELLIGENT MOLLUSK
An octopus is an agile predator with an advanced nervous system. Two-thirds of its neurons are located in its arms, which operate with a remarkable degree of independence from its brain. Experiments show that it also has considerable problem-solving intelligence, and excellent long- and short-term memories.

^ **FUNNEL, OPEN AND CLOSED**
On one side of the mantle, just behind the head, is a funnel, which the octopus uses in three ways: to expel water after gills have extracted oxygen; to rapidly discharge water as jet propulsion for a quick getaway; and to squirt a confusing cloud of ink at the enemy before fleeing.

v **UNDERSIDE**
The octopus is a cephalopod, which literally means "head-footed." Its eight mobile arms radiate from the underside of the head, where the mouth can be seen at the center.

< **SKIN**
The skin contains special cells called chromatophores. These contain pigment that can change the octopus's color — to blend in with its surroundings or to signal its mood if angry or afraid.

< **BEAK**
This octopus is a predator of crustaceans, among other prey. Its jaws are a parrotlike beak, which is strong enough to penetrate the tough carapace of a crab or lobster.

^ **SUCKER**
Each arm has two series of suckers. These give the octopus an excellent grip, allowing it to negotiate the sea bottom and coral reefs with ease. The suckers also have receptors that enable the octopus to taste what it is touching.

prominent eye with a horizontal, slit-shaped pupil
tough, warty skin can change color, texture, and shape for camouflage
long, muscular arms for moving over the sea bed and grasping objects
cuplike suckers

4–6 in
10–15 cm

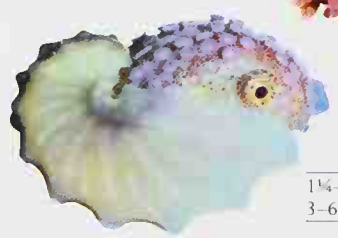
VAMPIRE SQUID
Vampyroteuthis infernalis
F: Vampyroteuthidae

This deep-sea cephalopod—with characteristics seemingly intermediate between squid and octopus—has fins projecting from its mantle and light-producing organs covering the body.

8 in
20 cm

DUMBO OCTOPUS
Grimpoteuthis plena
F: Grimpoteuthidae

Named for its earlike fins used in swimming, this cephalopod lives at depths of 10–13,000 ft (3–4,000 m), preying on other invertebrates.



1¼–2¼ in
3–6 cm

WINGED ARGONAUT
Argonauta hians
F: Argonautidae

Argonauts—also known as paper nautiluses—are octopus relatives. Females produce paper-thin egg cases that resemble shells. This species is distributed widely around the world.

6½ ft
2 m

NORTH PACIFIC GIANT OCTOPUS
Enteroctopus dofleini
F: Octopodidae

Perhaps the largest of all octopuses, this animal is surprisingly short-lived. Females are diligent caretakers of their huge broods.

2 in
5 cm

PACIFIC LONG-ARMED OCTOPUS
Octopus sp.
F: Octopodidae

One of several octopuses with especially long arms, adults of this species frequent sandy lagoons, but translucent juveniles live among oceanic plankton.

39–59 in
1–1.5m

CARIBBEAN REEF OCTOPUS
Octopus briareus
F: Octopodidae

An octopus of the western Atlantic and Caribbean, this coral-dwelling species often traps its prey by spreading its webbed arms like a net.

4½ ft
1.3 m

COMMON OCTOPUS
Octopus vulgaris
F: Octopodidae

Globally widespread in tropical and warm temperate waters, this octopus typically has a warty body and two rows of suckers on its arms.

20–28 in
50–70 cm

ATLANTIC OCTOPUS
Octopus sp.
F: Octopodidae

DNA analysis has revealed a number of similar octopus species, including this one, that are related to the common octopus, revealing hidden biodiversity.

6–8 in
15–20 cm

BLUE-RINGED OCTOPUS
Hapalochlaena lunulata
F: Octopodidae

This octopus preys on crustaceans and fish in the western Pacific, paralyzing them with venomous saliva that is also potentially fatal to humans.

black and blue ring markings warn that this is a highly venomous species

39 in/1 m

MIMIC OCTOPUS
Thaumoctopus mimicus
F: Octopodidae

Many octopuses can change color, but this Asian species can change shape too—even disguising itself to look like other marine animals such as sponges, corals, and jellyfish.

CHITONS

Flattened, rock-hugging chitons are among the most primitive of mollusks. Most are grazers of algae and microbe films, and occur in coastal waters.

A chiton's shell, popularly known as a "coat-of-mail" shell, is made up of eight interlocking plates that are sufficiently flexible to allow the animal to bend when gliding over uneven rocks—or even to roll up when disturbed. Chitons have no eyes or tentacles, although the shell itself contains cells that enable them to react to light. The plates are fringed by the edge of the mantle, known as the girdle. The mantle forms a fleshy skirt around the chiton. This overhangs grooves running down each side, which channel water, delivering oxygen to gills that project into the grooves. The radula, or rasping tongue, is coated with minute teeth reinforced with iron and silica, so chitons can graze on the toughest encrusting algae.

PHYLUM	MOLLUSCA
CLASS	POLYPLACOPHORA
ORDERS	4
FAMILIES	10
SPECIES	About 850

3¼ in/8 cm

MARBLED CHITON
Chiton marmoratus
F: Chitonidae

Like other chitons, the shell plates of this Caribbean mollusk are composed entirely of a chalky mineral called aragonite.

1½–2 in/4–5 cm

GREEN CHITON
Chiton glaucus
F: Chitonidae

A variable-colored chiton, this species occurs along the coastlines of New Zealand and Tasmania and, like most chitons, is active at night.

1–1½ in/2–3 cm

WEST INDIAN FUZZY CHITON
Acanthopleura granulata
F: Chitonidae

This spiky-fringed Caribbean chiton can tolerate exposure to sun, and can live high up in the intertidal zone.

1 in/2.5 cm

DECKED CHITON
Ischnochiton comptus
F: Ischnochitonidae

Ischnochiton chitons have a spiny or scaly girdle fringe. This is a common intertidal species of western Pacific shores.

LINED CHITON
Tonicella lineata
F: Ischnochitonidae

This brightly colored chiton occurs on North Pacific coasts, where it may be camouflaged when feeding on red encrusting algae.

¼–2 in
4–5 cm

12–13 in
30–33 cm

GUMBOOT CHITON
Cryptochiton stelleri
F: Acanthochitonidae

In one chiton family the fleshy girdle overlaps the chain mail plates. In this North Pacific species, the largest chiton, it forms a leathery skin.

2–3½ in/5–8 cm

BRISTLED CHITON
Mopalia ciliata
F: Mopaliidae

Named for its prominent hairy girdle, this chiton of the Pacific coast of North America is sometimes found beneath long-moored boats.

1½–2¾ in/4–7 cm

HAIRY CHITON
Chaetopleura papilio
F: Ischnochitonidae

A bristly-girdled species with brown-striped chainmail plates, the hairy chiton is found beneath rocks on South African coasts.

TUSK SHELLS

Curious, mud-shoveling tusk shells live in marine sediments and have a tubular curved shell—open at both ends and unlike the shell of any other mollusk.

PHYLUM	MOLLUSCA
CLASS	SCAPHOPODA
ORDERS	3
FAMILIES	12
SPECIES	About 500

Tusk shells are common, but are rarely seen because they usually occur far offshore, with the wide base of the hollow tusk buried in mud. The eyeless head and foot reach deeper into the sediment, probing for food with their tentacle-like structures called captacula, and tasting the mud with chemical detectors. When food is found—small invertebrates or detritus—the tentacles bring it to the mouth, where it is ground up by the radula, a rasping tongue typical of mollusks. Tusk shells lack gills; the animal's fleshy mantle encloses a water-filled, oxygen-extracting tube that runs the length of the shell. When levels of oxygen run low, the tusk shell contracts its foot and squirts the stale water out through the top end of the shell. Freshwater enters by the same route.

1¼–1½ in
3–4 cm

EUROPEAN TUSK
Antalis dentalis
F: Dentaliidae
O: Dentalida

This tusk shell of the northeast Atlantic is widespread in sandy areas of coastal waters. In places its empty shells are found in huge numbers.

2–3½ in
5–8 cm

BEAUTIFUL TUSK
Pictodentalium formosum
F: Dentaliidae
O: Dentalida

This colorful tropical tusk shell has been recorded in marine sediments in Japan, the Philippines, Australasia, and New Caledonia.

ECHINODERMS

Echinoderms include an astonishing array of sea creatures, ranging from filter-feeding feather stars to grazing urchins and predatory starfish.

This is the only large invertebrate phylum entirely restricted to saltwater. Echinoderms are sluggish, slow-moving inhabitants of the seafloor and most have a body form built around a five-part radial symmetry. Echinoderm means "spiny-skinned"—a reference to the hard, calcified structures, called ossicles, that make up the internal skeleton of these animals. In starfish these are spaced out within the soft tissue so that the animal is reasonably flexible, but in urchins they are fused together to form a solid internal shell. In sea cucumbers the ossicles are so minute and sparsely distributed—or even absent altogether— that the entire animal is soft-bodied.

HYDRAULIC FEET

Echinoderms are the only animals with a water transport system. Seawater is drawn into the center of the body through a perforated, sievelike plate, usually on the upper surface of the body. The water circulates through tubes that run through the animal and is forced into tiny soft projections near the surface, called tube feet, that can move back and forth and stick to surfaces. In feather stars these tube feet point upward on the feathery arms, capturing particles of food, which are then moved toward the central mouth. In other echinoderms thousands of downward-pointing tube feet are used in locomotion—together they pull the animal over sediment and rock.

DEFENSE

The tough prickly skin of most echinoderms offers good protection from potential predators, but these animals defend themselves in other ways too. Many urchins are covered with formidable spines, too; some can inflict serious wounds in humans. Many have tiny pincerlike projections, sometimes venomous, that can remove cluttering debris as well as deter potential predators. Soft-bodied sea cucumbers rely instead on noxious chemicals to protect themselves—and are often brightly colored as a warning. As a last resort, some sea cucumbers can even spew out sticky tangles or eject their gut.

PHYLUM	ECHINODERMATA
CLASSES	5
ORDERS	31
FAMILIES	147
SPECIES	About 7,000

The tiny tube feet on which echinoderms move around the seabed are seen here on a crown of thorns starfish, *Acanthaster planci*.

FEATHER STARS

A feather star carries five basic filter-feeding arms, which in some species branch into a dense cluster. A mouth and anus point upward from the center of the star. Some members of the class Crinoidea crawl along on moving fingerlike roots. Others, known as sea lilies, are attached by a stalk.

4–6 in
10–15 cm

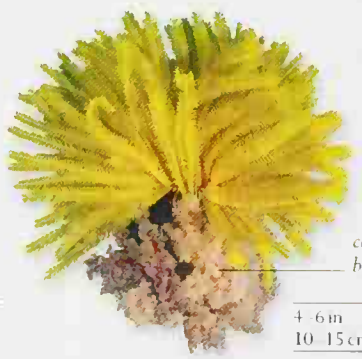
PRETTY FEATHER STAR
Cenometra emendatrix
F: Colobometridae

The arms of a feather star are fringed with smaller branches called pinnules that catch particles of food more effectively. In this tropical Pacific species they are white.

4–8 in
10–20 cm

GOLDEN FEATHER STAR
Davidaster rubiginosus
F: Comasteridae

Like other crinoids, this species from the western Atlantic is a suspension feeder, catching plankton with its feathery arms.



4–6 in
10–15 cm

YELLOW FEATHER STAR
Oxycomanthus bennetti
F: Comasteridae

Like many crinoids, this common western Pacific species filter feeds most voraciously at night and when underwater currents are strongest.

4–6 in
10–15 cm

RED FEATHER STAR
Himerometra robustipinna
F: Himerometridae

This feather star inhabits tropical Indo-Pacific coastal waters, clinging to corals and sponges. The pale clingfish lives among its arms, probably for protection from predators.

URCHINS AND RELATIVES

Sea urchins, which belong to the class Echinoidea, gave their name to the whole phylum. The hard ossicles of an urchin are plates that interlock to form a shell called a test. The animal's spines help in locomotion and defense. The mouth generally faces downward and the anus upward—with rows of tube feet running between the two.

4–4½ in
10–11 cm

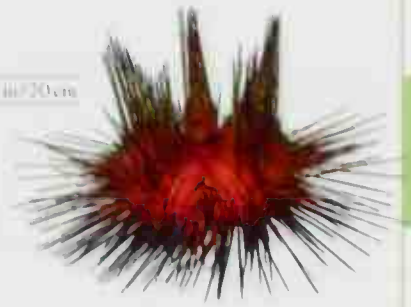
INDO-PACIFIC SAND DOLLAR
Echinodiscus auritus
F: Astrichypeidae

This Indo-Pacific urchin of coastal sands is a typical member of a group of burrowing sea dollars, named for their flattened appearance.

1½–2 in
4–5 cm

BANDED SEA URCHIN
Echinothrix calamaris
F: Diadematidae

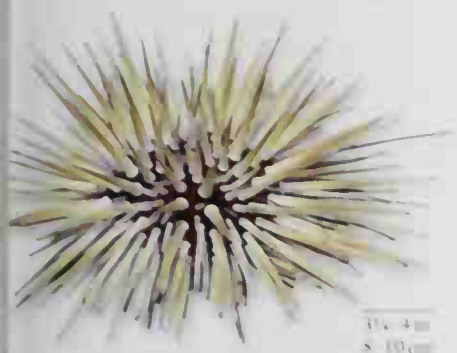
The shorter spines of this Indo-Pacific reef-dwelling urchin are painfully venomous. Cardinal fish (Apogonidae) often hide among them for protection.



8 in/20 cm

RED URCHIN
Astropyga radiata
F: Diadematidae

This Indo-Pacific lagoon species belongs to a family of tropical urchins with long hollow spines. It is often carried by a crab, *Dorippe frascone*.



3½–4 in
8–10 cm

MATHA'S URCHIN
Echinometra mathaei
F: Echinometridae

This Indo-Pacific species belongs to a group of urchins characterized by thick spines. It lives in crevices on coral reefs.

6½–7 in
16–18 cm

EDIBLE URCHIN
Echinus esculentus
F: Echinidae

This large globular urchin common on northeast Atlantic coasts has a variable color. It grazes on algae, especially kelp.

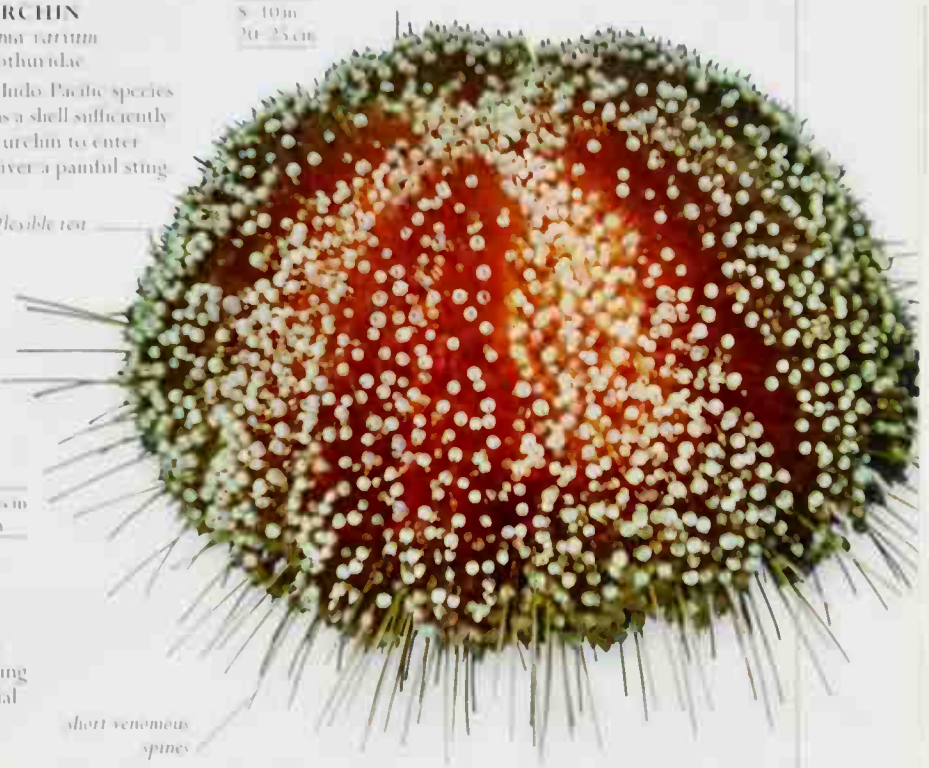
FIRE URCHIN
Asthenosoma varium
F: Echinothuriidae

This somewhat flat Indo-Pacific species of sandy lagoons has a shell sufficiently flexible for the urchin to enter crevices. It can deliver a painful sting.

8–10 in
20–25 cm

flexible test

short venomous spines



2½–3½ in
7–8 cm

SEA POTATO
Echinocardium cordatum
F: Loveniidae

Heart urchins, such as this globally widespread species, are detritus-feeding burrowers that lack the obvious radial symmetry of other urchins.

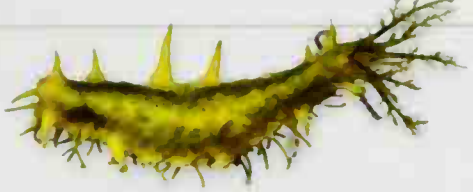
5½–4 in/8–10 cm

PURPLE URCHIN
Strongylocentrotus purpuratus
F: Strongylocentrotidae

An inhabitant of the underwater kelp forests along the Pacific coast of North America, this urchin is often used in biomedical research.

SEA CUCUMBERS

Sea cucumbers are soft tubular animals, with a mouth surrounded by a ring of food-collecting tentacles at one end, and an anus at the other. Some Holothuroidea shovel or burrow in sediments using their tentacles; others use rows of tube feet to crawl along the seabed.



2–3½ in
5–8 cm

YELLOW SEA CUCUMBER
Colochirus robustus
F: Cucumariidae

This echinoderm belongs to a family of thick-skinned sea cucumbers. Like this Indo-Pacific species, many are covered in knobbly projections.

6–7 in
15–18 cm

SEA APPLE CUCUMBER
Pseudocolochirus violaceus
F: Cucumariidae

Sea apples are brightly colored, highly poisonous, reef-dwelling sea cucumbers. This species has yellow or orange tube feet, but variable body color.

warning coloration

sticky mass ejected to repel predators

15–23½ in
38–60 cm

OCELLATED SEA CUCUMBER
Bohadschia argus
F: Holothuriidae

Distributed from the western Indian Ocean around Madagascar to the South Pacific, this large species is variable in color, but is always spotted.

10–12 in/25–30 cm

EDIBLE SEA CUCUMBER
Holothuria edulis
F: Holothuriidae

Large sea cucumbers are especially abundant in tropical waters. This Indo-Pacific species is harvested and dried for human consumption.

24 in
60 cm

VERMIFORM SEA CUCUMBER
Synapta maculata
F: Synaptidae

Typical of its family, this Indo-Pacific species is a soft-bodied, wormlike sea cucumber that burrows in soft sediment. It lacks tube feet.

spikes provide grip on mean floor

14–16 in
35–40 cm

GIANT CALIFORNIA SEA CUCUMBER
Stichopus californicus
F: Stichopodidae

One of the largest sea cucumbers of North America's Pacific coast, this fleshy spiked species is fished in a local delicacy.

2½–3½ in
60–75 cm

PRICKLY REDFISH
Thelenota anana
F: Stichopodidae

This echinoderm belongs to a family of sea cucumbers covered in fleshy spikes. It occurs on sandy seabeds around Indo-Pacific coral reefs.

12 in
30 cm

DEEP SEA CUCUMBER
Kolga hyalina
F: Elpidiidae

Virtually worldwide in distribution at depths of up to 5,000 ft (1,500 m), this is one of many little-known sea cucumbers found on ocean floors.

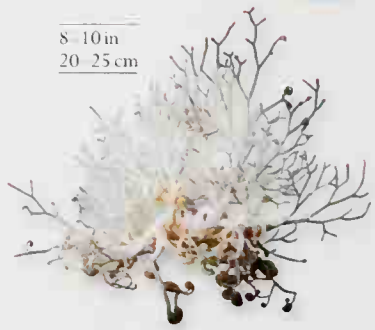
BRITTLE STARS

These animals are named for the fact that their long, thin, sometimes branching, arms easily break off. There is one opening to the gut in the central disk—a downward-facing mouth. Some Ophiuroidea use their arms to trap food particles; others are predatory.

SHORT-SPINED BRITTLE STAR
Ophioderma sp.
F: Ophiodermatidae
A brittle star of western Atlantic coastal waters, this species lives in submerged grass beds, where it preys on other invertebrates, such as shrimp.

COMMON BRITTLE STAR
Ophiothrix fragilis
F: Ophiotrichidae
This northeast Atlantic brittle star—often found in dense populations—has spiny arms, some of which it holds up to trap food particles.

BLACK BRITTLE STAR
Ophiocoma nigra
F: Ophiocomidae
This large brittle star of European waters can either filter feed on particles or scavenge on detritus. It can be common on rocky coasts with strong currents.



GORGON'S HEAD BRITTLE STAR
Gorgonocephalus caputmedusae
F: Gorgonocephalidae
This species, named for its coiled, snakelike branching arms, is common around European coasts. Larger animals are found in places of strong current, where they can collect more food.

STARFISH

Like most other echinoderms, starfish crawl on the seabed using their rows of tube feet. These run along grooves in the starfish's arms. Most species of Asteroidea are five-armed, but a few have more than five arms, and some are virtually spherical in shape. Many prey on other slow-moving invertebrates; others scavenge or feed on detritus. Although their skins are studded with hard ossicles, starfish are sufficiently flexible to catch prey.

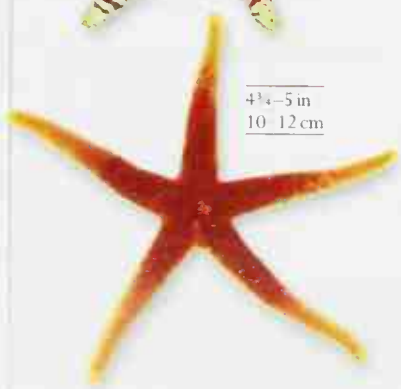
PURPLE SUNSTAR
Solaster endeca
F: Solasteridae
Sunstars are large spiny starfish with many arms. Living on offshore mud in the cold waters of the northern hemisphere, this species has from 7 to 13 arms.

SEVEN ARM STARFISH
Luidia ciliaris
F: Luidiidae
Unlike most other starfish, this large Atlantic species has seven arms. It has long tube feet and is fast moving in its pursuit of other echinoderms.

MOSAIC STARFISH
Plectaster decanus
F: Echinasteridae
Like a number of other members of its family, this striking species of southwest Pacific rocky coasts varies greatly in color.

WARTY STARFISH
Echinaster callosus
F: Echinasteridae
Belonging to a family of stiff-bodied starfishes with conical arms, this western Pacific species is unusual for its pink and white warts.

GIANT SUNFLOWER STARFISH
Pycnopodia helianthoides
F: Pycnopodiidae
One of the world's largest starfish, this many-armed species preys on mollusks and other echinoderms. It lives among offshore seaweed on the northeast Pacific coast.



BLOOD HENRY STARFISH
Henricia oculata
F: Echinasteridae
This relative of the warty starfish lives in tidal pools and kelp forests of the northeast Atlantic. Its body varies

OCHER STARFISH
Pisaster ochraceus
F: Asteriidae
This North American Pacific relative of the common Atlantic starfish—like others of its family—hunts invertebrates. It is an important predator of mussels.

COMMON STARFISH
Asterias rubens
F: Asteriidae
This common northeast Atlantic predator of other invertebrates is unusual among echinoderms in tolerating estuarine conditions. It often occurs in huge local populations.

ICON STARFISH
Iconaster longimanus
F: Goniasteridae
Many echinoderms develop from planktonic larvae, but this Indo-Pacific starfish lacks a larval stage. It produces large yolky eggs.

20–24 in / 50–60 cm

CROWN OF THORNS STARFISH
Acanthaster planci
F: Acanthasteridae

This giant Indo-Pacific starfish is a predator of coral polyps, threatening some reef ecosystems. It has 10–20 arms and sharp, mildly venomous spines that can cause injury to humans.

venomous spines

8–12 in
20–30 cm

BLUE STARFISH
Linckia laevigata
F: Ophidiasteridae

Snake-armed starfish have smooth, spineless surfaces. This Indo-Pacific species is usually blue, but a minority are purple or orange. It frequently lives in association with detritus-eating shrimp.

8–10 in
20–25 cm

PURPLE STARFISH
Ophidiaster ophidianus
F: Ophidiasteridae

This snake-armed starfish occurs in warmer waters of the northeast Atlantic, on coarse seabeds around the Mediterranean and as far as West Africa.

4–4½ in
10–12 cm

NECKLACE STARFISH
Fromia monilis
F: Ophidiasteridae

Like many other members of the family, this snake-armed starfish is brightly colored to deter predators. It is an Indo-Pacific species, occurring as far west as the Red Sea.

10–12 in
25–30 cm

rows of red tubercles

RED GENERAL STARFISH
Protoreaster lincki
F: Oreasteridae

From the cushion star family, this Indian Ocean species grazes on algae as a juvenile, but preys on other invertebrates when adult.

8–10 in
20–25 cm

GRANULATED STARFISH
Choriaster granulatus
F: Oreasteridae

A giant Indo-Pacific echinoderm of rubble slopes and coral reefs, this cushion star grazes on algae and detritus in shallow waters.

8–10 in
20–25 cm

INDO-PACIFIC CUSHION STAR
Culcita novaeguineae
F: Oreasteridae

This coral-feeder of the Indo-Pacific belongs to a family of starfish that become shorter-armed as they get bigger, eventually maturing into dumpy cushion shapes.

10–17 in
25–30 cm

KNOBBLY STARFISH
Pentaceraster cumingi
F: Oreasteridae

This large strikingly patterned cushion star occurs on sandy and rubble-strewn sea bottoms of tropical central and eastern Pacific.

2¾–3¼ in
6–7 cm

CUMING'S PLATED STARFISH
Neoferdina cumingi
F: Ophidiasteridae

All snake-armed starfish have rows of granular plates on their upper surfaces, but these are especially conspicuous in plated sea stars, such as this Pacific species.

RED CUSHION STAR
Peramia pulvillus
F: Poramiidae

This distinctive smooth-topped starfish with short arms and fringe of spines occurs on European rocky coasts, often on kelp holdfasts.

6–8 in / 15–20 cm

GOOSEFOOT STARFISH
Anseropoda placenta
F: Asterinidae

A thin flat starfish with ill-defined arms, the goosefoot starfish of the eastern Atlantic is a predator of bottom-dwelling crustaceans.

groups of stiff spines on short, blunt arms

1½–2 in
4–5 cm

SMALL CUSHION STAR
Asterina gibbosa
F: Asterinidae

This short-armed variable-colored starfish, from the same family as the goosefoot, scavenges dead material on the rocky coasts of the northeast Atlantic.

4–4½ in
10–12 cm

CHORDATES

Less than three percent of animal species are chordates, yet they include the largest, fastest, and most intelligent animals alive today. Most chordates have skeletons made of bone, but their defining feature is a rodlike structure called a notochord—the evolutionary forerunner of the spine.

The earliest known chordates were small, streamlined animals, with bodies just a few inches long. Living over 550 million years ago, they had no hard parts, except for a stiff but flexible cartilaginous notochord. The notochord ran the length of their bodies, creating a framework for their muscles to pull against. Today's chordates have all inherited this feature, and a small number keep it throughout life. However, in the vast majority of chordates—from fish and amphibians to reptiles, birds, and mammals—the notochord is present only in the early embryo. As the embryo develops, the notochord disappears, replaced by an internal skeleton made of cartilage or bone. These animals are known as vertebrates, from the column of vertebrae that makes up their spines.

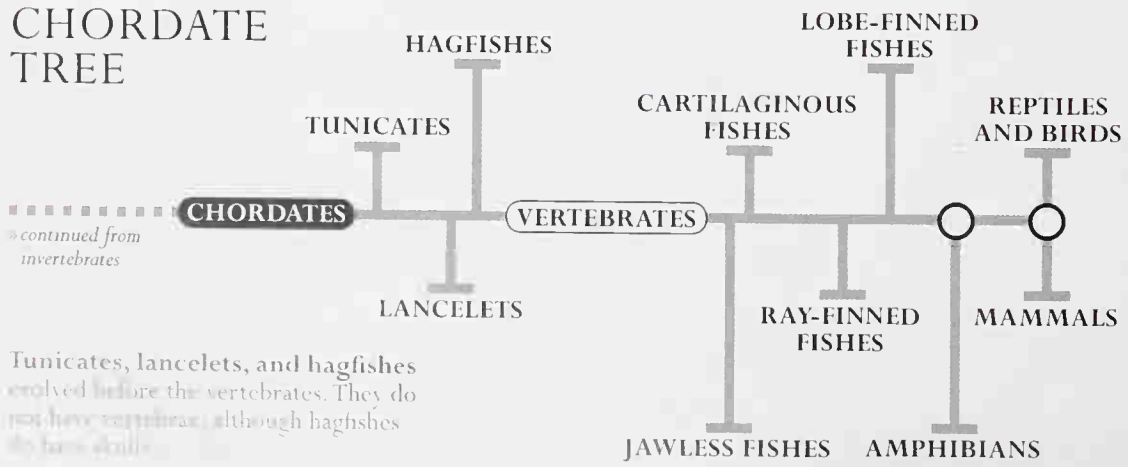
Unlike shells or body cases, bony skeletons work on an amazing spectrum of scales. The smallest vertebrate, a freshwater fish called *Paedocypris progenetica*, is less than ⅜ in (1 cm) long and weighs several billion times less than a blue whale, which is the largest chordate, and the biggest animal that has ever lived.

LIFESTYLES

Some of the simplest chordates, such as sea squirts, do not have skeletons, and spend their adult lives fastened in one place. But they are an exception. Chordates generally—and vertebrates in particular—are often fast-moving animals, with rapid reactions, well-developed nervous systems, and sizable brains. Birds and mammals use energy from food to keep their bodies at a constant optimum temperature.

Chordates vary in breeding techniques and in the way they raise their young. Apart from mammals, most vertebrates spawn or lay eggs, although species bearing live young exist in almost every vertebrate group apart from birds. The number of offspring produced is directly related to the amount of parental care. Some fish produce millions of eggs, and play no part in raising their young, whereas mammals and birds have much smaller families.

CHORDATE TREE



Tunicates, lancelets, and hagfishes evolved before the vertebrates. They do not have vertebrae, although hagfishes do have skulls.

TUNICATES
The subphylum Tunicata contains about 3,000 species. Larval tunicates have a notochord, and resemble tadpoles. The adults are filter feeders, the most common type being sea squirts.

AMPHIBIANS
Numbering over 6,000 species, amphibians include frogs and toads, salamanders, newts, and caecilians. Most start their lives as aquatic larvae, but as adults they take up life on land.

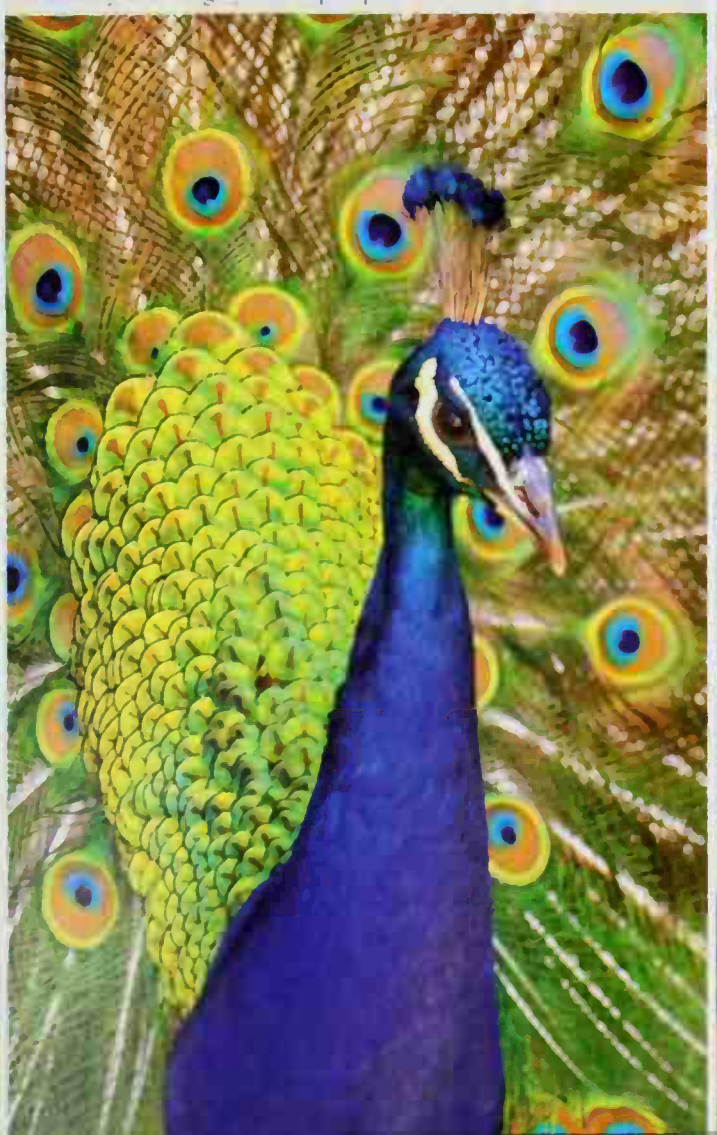
LANCELETS
Small marine animals with slender bodies and a notochord throughout life, lancelets live half buried in the seabed. There are 20 species in the subphylum Cephalochordata.

HAGFISHES
These eel-like, seabed scavengers belong to the subphylum Craniata, which includes all animals with skulls. Unlike other craniates, the 60 species of hagfish lack a backbone.

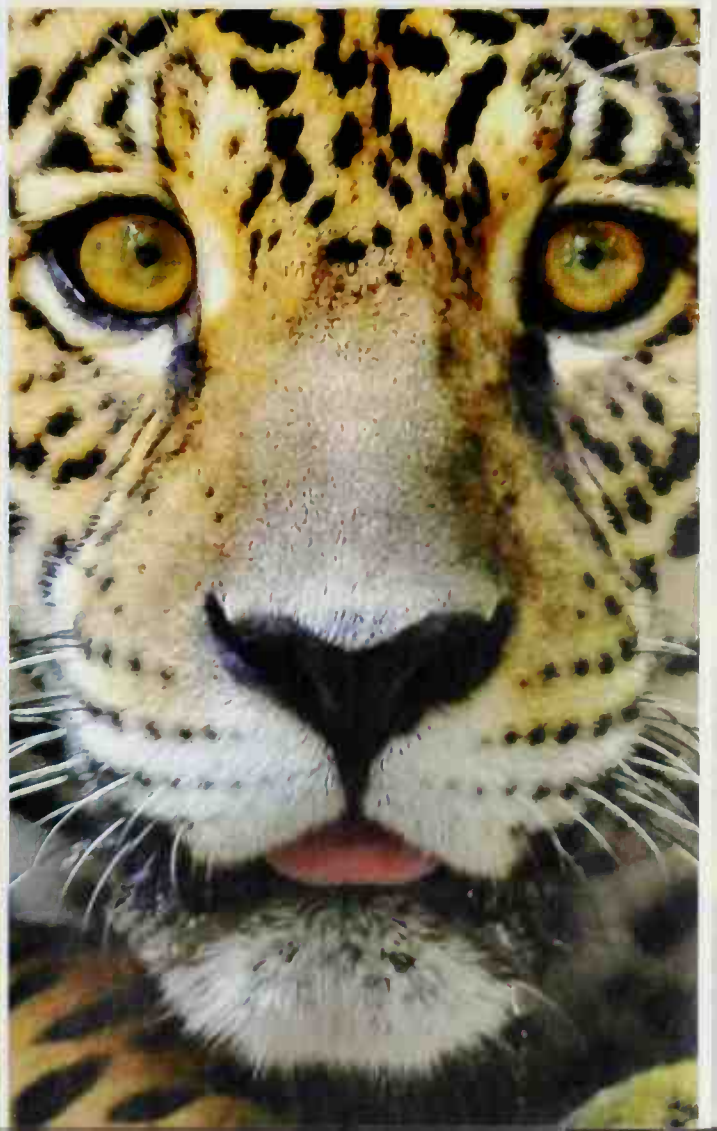
FISH
Fish were the earliest animals to evolve vertebrae. They are classified in several different classes, reflecting their varied evolutionary past. Over 30,000 living species are known.

REPTILES
With nearly 8,000 species, reptiles inhabit every continent on Earth, with the exception of Antarctica. Unlike birds and mammals, they are cold-blooded, and covered in scales.

BIRDS
Birds are the only living animals that have feathers. There are around 10,000 species of birds. All of these lay eggs, and many show highly developed parental care.



MAMMALS
Readily identified by their fur, mammals are the only chordates that raise their young on milk. There are about 5,400 known mammal species.



FISH

Fish are the most diverse chordates and can be found in all types of watery habitat—from tiny freshwater pools to the deep ocean. Almost without exception, they breathe using feathery gills to absorb oxygen from the water, and almost all swim using fins.

PHYLUM	CHORDATA
CLASSES	PETROMYZONTIDA CHONDRICHTHYES ACTINOPTERYGII SARCOPTERYGII
ORDERS	63
FAMILIES	538
SPECIES	31,254

Overlapping scales cover the body of a bicolor parrotfish, forming a flexible layer that protects against injury.

Predatory sharks lunge into a huge school of sardines, which swim ever closer together for protection.

The huge mouth of a male gold-specs jawfish provides an unlikely nest for its eggs. He will not feed during incubation.

Fish are not a natural, single group but are in fact four classes of vertebrate chordates, of which the familiar ray-finned (bony) fishes are by far the most populous. The majority of fishes are cold-blooded so their body temperature matches that of the surrounding water. A few top predators, such as white sharks, can maintain a flow of warm blood to the brain, eyes, and main muscles, which allows them to hunt actively even in very cold water. Most fishes are protected by scales or bony plates embedded in the skin. In fast swimmers these are lightweight, and provide streamlining as well as protection from abrasion and disease. Although a few fishes slither or shuffle over the seabed, most swim using fins. With the notable exception of rays, the tail fin usually provides the main propulsive force. Paired pectoral and pelvic fins (on the sides and underside respectively) provide stability and maneuverability, helped by up to three dorsal fins on the fish's upper side and one or two anal fins. Fishes avoid collisions—especially when in large schools—by using special sensory organs that detect the vibrations made as they or other animals move through the water. Most fishes have a row of these organs running along both sides of the body, called the lateral line. While they also use the senses of hearing, touch, sight, taste, and smell found in other chordates, only fishes have a lateral line system.

REPRODUCTIVE STRATEGIES

The four classes of fish have very different ways of reproducing. Most ray-finned fishes, and some lobe-finned fishes, have external fertilization and shed masses of eggs and sperm directly into the water to compensate for the huge numbers that are eaten or die before they can develop into juvenile fishes. In contrast, cartilaginous fishes (sharks, rays, and chimaeras) have internal fertilization and produce eggs or young at an advanced developmental stage. This requires a high input of energy—only a few young are produced at one time, but these have a good chance of survival. The eggs of lamprey (jawless fishes) hatch into larvae that live and feed for many months before undergoing metamorphosis into the adult form.

BRIGHT SPECTACLE >
The fabulous colors of the Banggai cardinalfish, seen here sheltering among giant anemones, attract aquarium owners.

FISH GROUPS

The four classes show fundamental differences, especially in skeleton and gills, but also many similarities in body form required to function in an aquatic environment.

JAWLESS FISHES

» 322

CARTILAGINOUS FISHES

» 323

RAY-FINNED FISHES

» 330

LOBE-FINNED FISHES

» 349

JAWLESS FISHES

Unlike all other vertebrates, jawless fishes have no biting jaws, although they do have teeth. This ancient group has only a few living representatives.

Instead of jaws, lampreys have a circular sucker disk at the end of the snout with concentric rows of rasping teeth. A row of seven small, circular gill openings runs along each side of the body just behind the eyes. Their skin is smooth with no scales and they have either one or two separate dorsal fins on the back near the tail. Lampreys have a cranium—a skull without jaws—but it is made of cartilage. They lack a bony skeleton and have only a partially formed vertebral column. A flexible rod—the notochord—supports the body.

DIFFERING LIFECYCLES

Lampreys live in temperate coastal waters and freshwaters worldwide. All species breed in freshwater. The coastal species are anadromous fish—that is, like salmon, they swim up rivers into freshwater to spawn, after which they die. The eggs hatch into wormlike, burrowing larvae, known as ammocoetes. These live in mud and feed on detritus. After about three years the larvae of the anadromous species change into adults and swim out to sea, where they feed for several years. The freshwater species remain in rivers and lakes.

UNWELCOME PARASITES

Lampreys are notorious for feeding parasitically on larger fish when they are adult. Clinging on with its sucker mouth, a lamprey grinds its way through its victim's skin, eating both flesh and blood. They can be a nuisance to fishermen because they damage and kill fish in nets and fish farms. However, most lampreys are not totally reliant on sucking blood but also eat invertebrates. In freshwater there are some completely nonparasitic species. These reproduce up to six months after undergoing metamorphosis from the larval to the adult form but the adults do not feed. The sucker mouth is also useful when the fish are swimming upstream against the current—they use it to cling onto rocks so they can have a rest.

Three fossil lamprey species dating from the late Carboniferous period have been found in the USA, and one of these appears to be very similar to living lampreys.

PHYLUM	CHORDATA
CLASS	PETROMYZONTIDA
ORDERS	1
FAMILIES	3
SPECIES	38

DEBATE

ARE LAMPREYS AND HAGFISHES RELATED?

Soft mud in the ocean depths is home to slimy scavengers called hagfishes. These too are jawless, eel-like fishes with no bony skeleton. But unlike lampreys, they have an underslung, slitlike mouth, only vestigial eyes, and eggs develop directly into miniature adults. Traditionally hagfishes and lampreys were classed together as Cyclostomata, separate from jawed vertebrates; this was the "cyclostome hypothesis." But detailed morphological comparisons led lampreys to be allied with the jawed vertebrates. The latest molecular studies, however, are supporting the cyclostome hypothesis.

LAMPREYS

Jawless fishes in the order Petromyzontiformes have a suckerlike mouth armed with concentric arcs of small, sharp teeth. The gills open through a row of seven circular openings on each side behind the eyes. All lampreys spawn in temperate rivers and streams, but some live in coastal waters.

SEA LAMPREY
Petromyzon marinus
F: Petromyzontidae
Salmon in the North Atlantic sometimes fall prey to this parasitic fish, which latches onto its victim and scrapes out its flesh.

FAR EASTERN BROOK LAMPREY
Lethenteron reissneri
F: Petromyzontidae
This dark brown lamprey from the northwest Pacific region is common in rivers and streams in Japan.

EUROPEAN RIVER LAMPREY
Lampetra fluviatilis
F: Petromyzontidae
Although able to live out at sea, this lamprey usually remains in estuaries in the northeast Atlantic and northwest Mediterranean.

BROOK LAMPREY
Lampetra planeri
F: Petromyzontidae
Larvae and adults of this common northern European lamprey live in streams and rivers. Once metamorphosis has taken place, the adults stop feeding and devote all their energy to spawning, after which they die.

PACIFIC LAMPREY
Lampetra tridentata
F: Petromyzontidae
Some populations of this lamprey are land-locked in lakes. Those in the ocean may suck blood and flesh from sperm whales.

CARTILAGINOUS FISHES

These fishes have a skeleton of pliable cartilage rather than the hard bone found in most other vertebrate groups. Most are predators with acute senses.

Sharks, rays, and chimaeras are all cartilaginous fishes although chimaeras have distinct anatomical differences from the other two groups. In chimaeras, the upper jaw is fused to the braincase and cannot be moved independently. They also have teeth that grow continuously. In contrast, sharks and rays regularly lose their hard enamel-covered teeth but replace them from extra rows lying flat behind the active teeth—a characteristic that helps make sharks some of the most formidable predators on Earth. The skin of all three groups—sharks, rays, and chimaeras—is protected by toothlike scales called dermal denticles.

SEARCHING FOR PREY

The ocean is home to most cartilaginous fishes and while most rays live on the seabed, the larger predatory shark species roam in open water. The bullshark and over 100 other species can enter estuaries and swim up rivers and a few live entirely in rivers. Open-water cartilaginous fishes are continually on the move because, unlike bony fish, they do not have a gas-filled swim bladder to maintain neutral buoyancy and therefore sink if they stop swimming. The whale shark and other surface-living species have a large oily liver to prevent this. Predatory sharks are well known for their amazing ability to smell blood and home in on wounded fish and mammals. Cartilaginous fishes also have the ability to detect the weak electrical fields that surround living creatures and while not unique to them, this sense is developed to an extraordinary extent in this group.

REPRODUCTION

All cartilaginous fishes mate and have internal fertilization. Chimaeras and some sharks and rays lay eggs, each protected by a tough egg capsule and commonly known as a "mermaid's purse." However, most sharks and skates give birth to well-developed live young that are nourished in the uterus by egg yolk or by a placental connection to the mother. Unlike mammals, the young are independent from birth and neither parent takes any interest in their offspring.

PHYLUM	CHORDATA
CLASS	CHONDRICHTHYES
ORDERS	12
FAMILIES	51
SPECIES	1,171

A white shark, *Carcharodon carcharias,* shows the continually developing rows of teeth that make it such a fearsome predator.

CHIMAERAS

Also known as rabbitfishes because of their fused platelike teeth, the Chimaeriformes are a small order of cartilaginous fishes with about 34 species. A strong, venomous spine in front of the first of two dorsal fins provides protection in their deepwater habitat.

4¾ ft
1.3 m

PACIFIC SPOOKFISH
Rhinochimaera pacifica
F: Rhinochimaeridae
The long, conical snout of this chimaera is covered in sensory pores that detect the electrical fields of its prey.

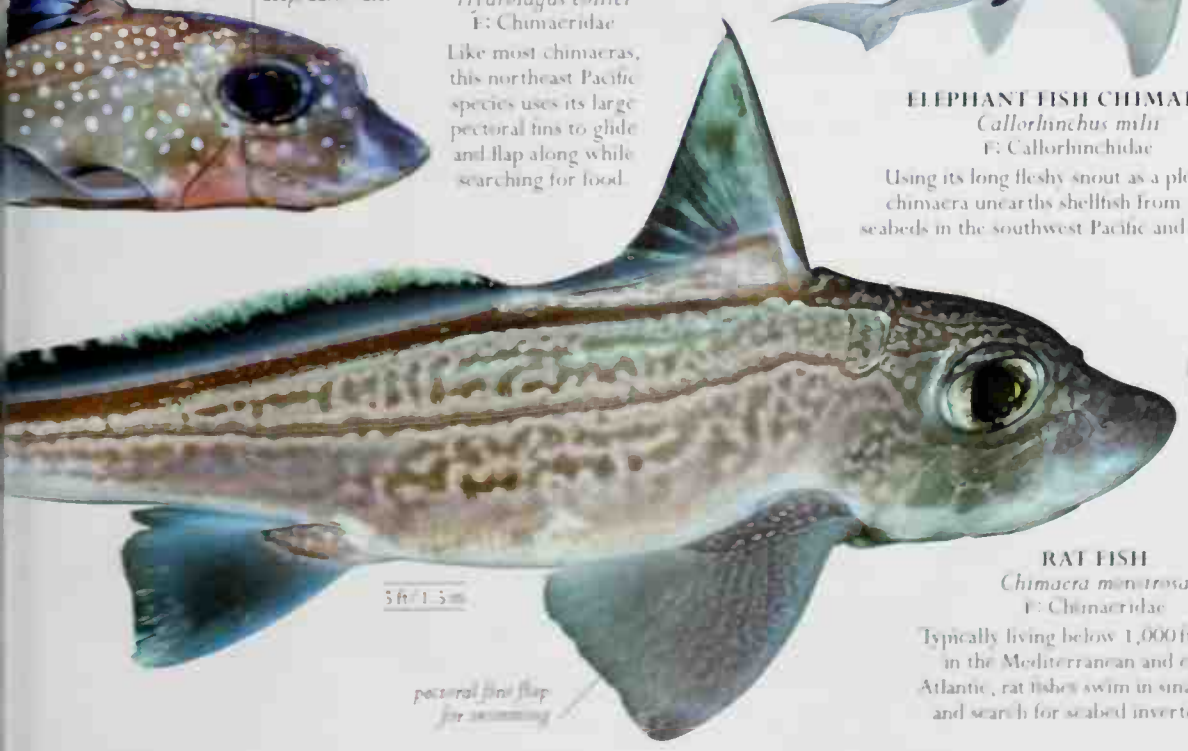
3¼ ft
1 m

large eye provides better vision in deep, dark water

SPOTTED RAT FISH
Hydrolagus colliei
F: Chimaeridae
Like most chimaeras, this northeast Pacific species uses its large pectoral fins to glide and flap along while searching for food.

4¾ ft
1.3 m

ELEPHANT FISH CHIMAERA
Callorhinchus milii
F: Callorhinchidae
Using its long fleshy snout as a plow, this chimaera unearths shellfish from muddy seabeds in the southwest Pacific and Australia.



3 ft / 1 m

pectoral fins flap for swimming

RAT FISH
Chimaera monstrosa
F: Chimaeridae
Typically living below 1,000 ft (300 m) in the Mediterranean and eastern Atlantic, rat fishes swim in small groups and search for seabed invertebrates.

SIX- AND SEVEN-GILL SHARKS

While most sharks have five pairs of gill slits, those of the order Hexanchiformes have either six or seven pairs. Also known as cow and frill sharks, they have a single dorsal fin on the back near the tail. The six known species live mainly in deep water.

18 ft
5.5 m

BLUNTNOSE SIXGILL SHARK
Hexanchus griseus
F: Hexanchidae
Rocky seamounts around the world are the haunt of this huge, green-eyed shark that weighs up to 1,325 lb (600 kg).

6½ ft
2 m

FRILLED SHARK
Chlamydoselachus anguineus
F: Chlamydoselachidae
Scattered records indicate this shark has a worldwide distribution. It has brilliant white teeth that may attract its prey of fish and squid.

DOGFISH SHARKS AND RELATIVES

A large and varied order, the Squaliformes contains at least 130 species and includes gulper, lantern, sleeper, rough, and kitefin sharks. These all have two dorsal (back) fins and no anal fin. All species so far studied bear live young.

PIKED DOGFISH
Squalus acanthias
F: Squalidae

Occurring worldwide in temperate waters this once abundant shark is now endangered. Living to an age of 100, it grows and breeds very slowly.

LARGETOOTH COOKIECUTTER SHARK
Isistius plutodus
F: Dalatiidae

In the western Atlantic and northwest Pacific, dolphins and large fish suffer attacks from this shark, which bites and twists out plugs of flesh, hence its name.

VELVET BELLY LANTERN SHARK
Etmopterus spinax
F: Etmopteridae

The lantern shark lives in the deep eastern Atlantic. It has tiny light organs on its belly, which help in finding a mate.

GREENLAND SHARK
Somniosus microcephalus
F: Somniosidae

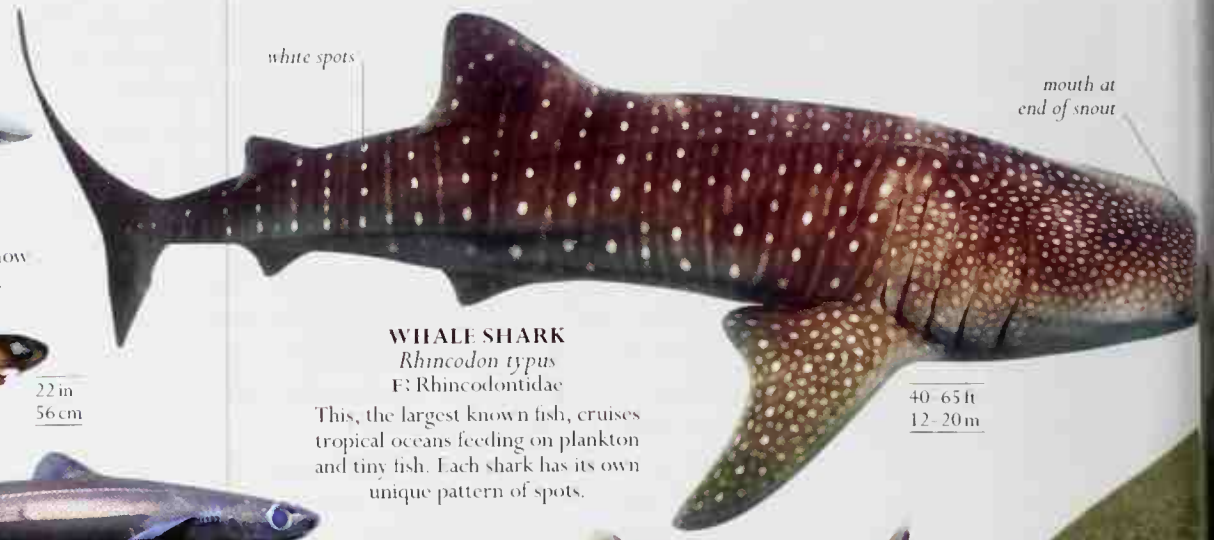
One of only a few sharks that live in Arctic waters, the Greenland shark often scavenges for drowned land animals.

ANGULAR ROUGHSHARK
Oxynotus centrina
F: Oxynotidae

This shark has two sail-like dorsal fins and rough skin. It lives in the eastern Atlantic at depths of at least 330 ft (100 m).

CARPET SHARKS

The 33 or so sharks of the Orectolobiformes have two dorsal fins, one anal fin, and sensory barbels hanging down from the nostrils. With the exception of the whale shark, they live quietly on the seabed, feeding on fish and invertebrates.

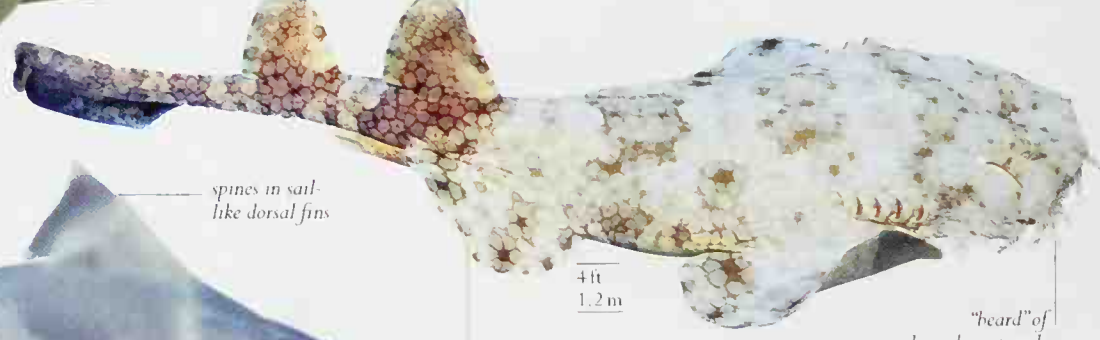


WHALE SHARK
Rhincodon typus
F: Rhincodontidae

This, the largest known fish, cruises tropical oceans feeding on plankton and tiny fish. Each shark has its own unique pattern of spots.

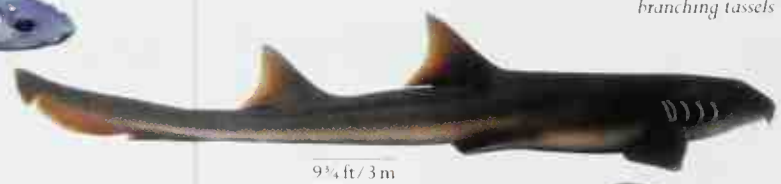
EPAULETTE CATSHARK
Hemiscyllium ocellatum
F: Hemiscyllidae

The boldly marked epaulette shark clambers among coral on its fins. This small shark has a long tail and lives in the South Pacific.



TASSELLED WOBBEGONG
Eucrossorhinus dasypogon
F: Orectolobidae

With its fringe of skin tassels, flattened body, and camouflage pattern, this southwest Pacific coral reef resident is hard to spot.

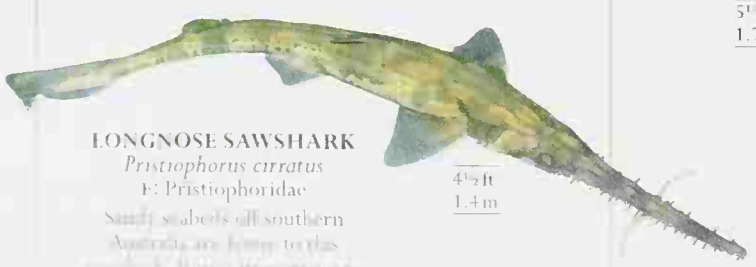


NURSE SHARK
Ginglymostoma cirratum
F: Ginglymostomatidae

By day this shark lies hidden in rock crevices, emerging at night to hunt in the warm coastal waters of the Atlantic and eastern Pacific.

SAWSHARKS

Sawsharks have a flat head with gills on the sides and a rostrum, a long snout edged with teeth like a saw. Two long sensory barbels hang from the rostrum and help find buried food. Most of the nine species of Pristiophoriformes live in the tropics.

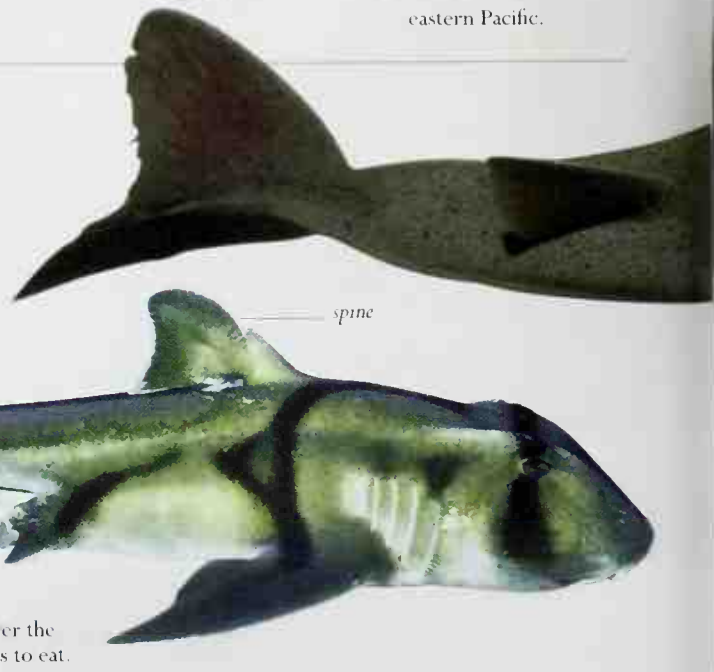


LONGNOSE SAWSHARK
Pristiophorus cirratus
F: Pristiophoridae

Small seabeds off southern Australia are home to this sawshark. It uses its rostrum to [illegible]

BULLHEAD SHARKS

The Heterodontiformes are small bottom-living sharks with paddlelike pectoral fins. They have a blunt, sloping head, crushing teeth, and two dorsal (back) fins each preceded by a sharp spine.



PORT JACKSON SHARK
Heterodontus portusjacksoni
F: Heterodontidae

Using its paddlelike front fins, this shark crawls over the seabed off southern Australia in search of sea urchins to eat.

ANGELSHARKS

Flattened from top to bottom, angelsharks have gill slits on the sides of their large head. This distinguishes the Squatiniformes from the similarly shaped rays, which have gills underneath. The order contains just one family, which has 13 members. Angelsharks use their large pectoral fins to rear up and ambush prey.

5 ft / 1.5 m

SAND DEVIL
Squatina dumeril
F: Squatinidae

Sandy seabeds in the northwest Atlantic are home to this well-camouflaged predator. It strikes at passing fish with lighting speed.

GROUND SHARKS

There are more than 225 species of Carcharhiniformes, making this the largest and most diverse order of sharks. Most are large predators, although the small yet numerous cat sharks are also included in the order. All have two dorsal fins and one anal fin.

13 ft / 4 m

BLUE SHARK
Prionace glauca
F: Carcharhinidae

Streamlined and elegant, this species travels vast distances between feeding and breeding grounds. More are fished than any other shark.

6½ ft / 2 m

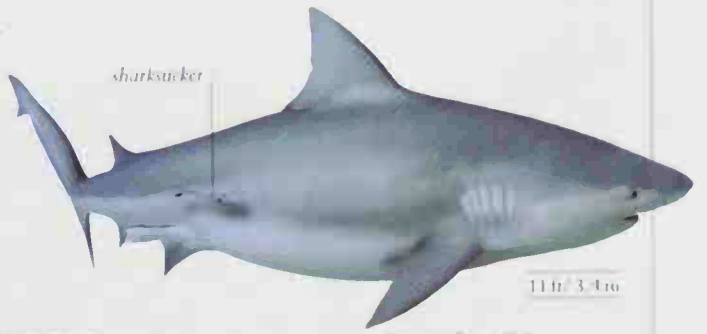
WHITETIP REEF SHARK
Triaenodon obesus
F: Carcharhinidae

This is perhaps the most common shark on the coral reefs of the Indian and Pacific oceans. It hunts fish at night, sometimes in frenzied packs.

13 ft / 4 m

OCEANIC WHITETIP SHARK
Carcharhinus longimanus
F: Carcharhinidae

The tall white-tipped first dorsal fin of this dangerous open-ocean wanderer is a sight greatly feared by shipwreck survivors.



11 ft / 3.4 m

BULL SHARK
Carcharhinus leucas
F: Carcharhinidae

One of the ocean's most dangerous sharks, this top predator inhabits tropical coastal waters worldwide and also swims up rivers.

25 ft / 7.5 m

TIGER SHARK
Galeocerdo cuvier
F: Carcharhinidae

Named for its stripes, which fade with age, the tiger shark will eat anything and has attacked humans. Its serrated teeth are shaped like a cockscomb.

»

» GROUND SHARKS

STARRY SMOOTH-HOUND
Mustelus asterias
F: Triakidae

This small, common shark of the northeast Atlantic has shiny skin and flat, slablike teeth, ideal for crushing crabs and shellfish.

SMALL-SPOTTED CATSHARK
Scyliorhinus canicula
F: Scyliorhinidae

Common in the northeast Atlantic, this small shark is one of more than 100 similar species in its family. Its egg cases are called mermaid's purses.

SMOOTH HAMMERHEAD
Sphyrna zygaena
F: Sphyrnidae

With its eyes at both ends of a T-shaped head, this shark has all-round vision. It is found worldwide in warm water.

MACKEREL SHARKS

The 15 species of shark in this order are large with cylindrical bodies and conical heads. The Lamniformes are efficient hunters and many of them can maintain a high body temperature, allowing them to sustain speed in cold waters.

SAND TIGER SHARK
Carcharias taurus
F: Odontaspididae

The menacing, daggerlike teeth of this large mackerel shark belie its docile nature. It lives in warm coastal waters.

GOBLIN SHARK
Mitsukurina owstoni
F: Mitsukurinidae

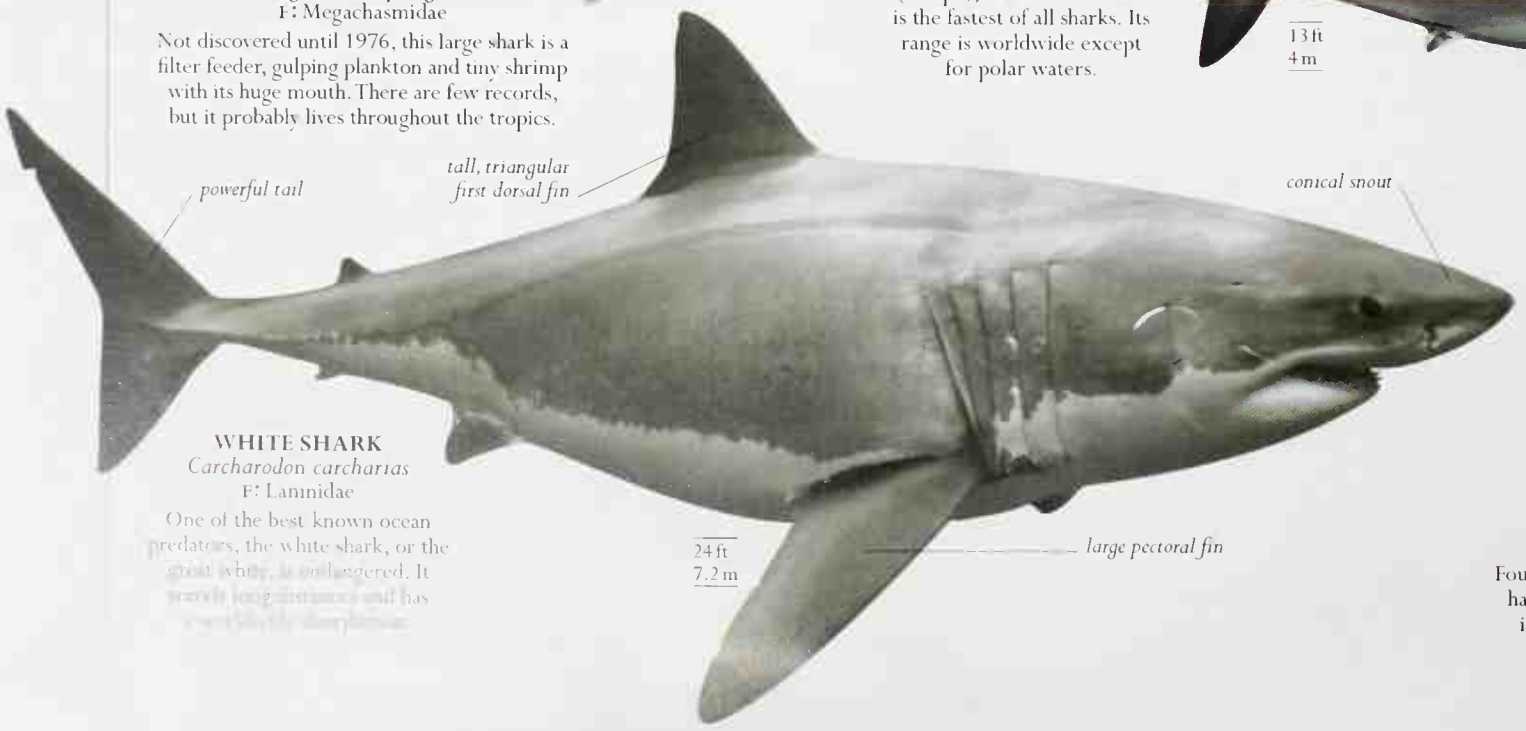
This shark has jaws that shoot forward to grab fish. Living in the dark depths of the Atlantic, Pacific, and western Indian oceans, it detects prey using its flat, electrosensitive, bill-like snout.

MEGAMOUTH SHARK
Megachasma pelagios
F: Megachasmidae

Not discovered until 1976, this large shark is a filter feeder, gulping plankton and tiny shrimp with its huge mouth. There are few records, but it probably lives throughout the tropics.

SHORTFIN MAKO
Isurus oxyrinchus
F: Lamnidae

Capable of reaching 20 mph (35 kph), the shortfin mako is the fastest of all sharks. Its range is worldwide except for polar waters.



WHITE SHARK
Carcharodon carcharias
F: Lamnidae

One of the best known ocean predators, the white shark, or the great white, is endangered. It travels long distances and has

THRESHER SHARK
Alopias vulpinus
F: Alopiidae

Found worldwide, the thresher shark has a tail as long as its body, which it lashes to herd and stun fishes.

SKATES AND RAYS

In this order of fishes, a flat, disk-shaped body and winglike pectoral fins joined to the head are adaptations for bottom-living. However, some members of the order Rajiformes are free-swimming. A long, thin tail helps them keep their balance when swimming. The tail is sometimes armed with a sting.

4½ ft
1.4 m

COMMON STINGRAY
Dasyatis pastinaca
F: Dasyatidae

While most stingrays live in the tropics, the range of this fish is from the Mediterranean into northern Europe, where it lives inshore on sediment.

35 in
90 cm

BLUE-SPOTTED RIBBONTAIL RAY
Taeniura lymma
F: Dasyatidae

Found on most coral reefs in the Indian Ocean and the western Pacific, this stingray has a venomous spine on its tail.

35 in
90 cm

THORNBACK RAY
Raja clavata
F: Rajidae

This European ray is protected from predators by the row of distinctive curved spines with wide bases that runs down its back.

9 ft
2.9 m

BLUE SKATE
Dipturus batis
F: Rajidae

The largest European ray, the blue skate preys upon midwater fish and seabed invertebrates. It is distinguished by its long, pointed snout and blue underparts.

13 ft
4 m

SPINY BUTTERFLY RAY
Gymnura altavela
F: Gymnuridae

This ray glides over the sea bed in the warmer parts of the Atlantic, searching for invertebrates and fishes.

20 in
50 cm

OCELLATE RIVER STINGRAY
Potamotrygon motoro
F: Potamotrygonidae

Unlike most rays, this South American stingray lives in freshwater. It inhabits rivers and is a danger to fishermen, as its tail delivers a painful sting.

23 in
58 cm

HALLER'S ROUND RAY
Urobatis halleri
F: Urotrygonidae

At home on shallow, sandy flats, the venomous spine on this stingray poses a threat to bathers. It is found in coastal waters from California to Panama.

11 ft
3.3 m

SPOTTED EAGLE RAY
Aetobatus narinari
F: Myliobatidae

This ray is found in tropical waters worldwide. It swims by beating its pectoral fins like a bird's wings.

huge, pointed "wings"

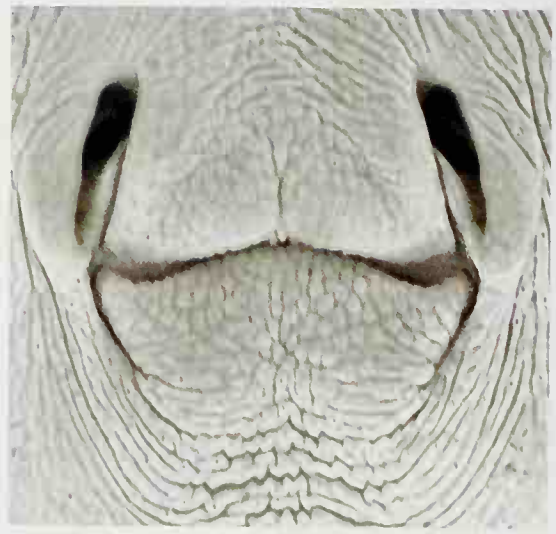
BLUE-SPOTTED RIBBONTAIL RAY

Taeniura lymma

Stingrays are notorious for the painful wounds they can inflict with their barbed tail, which can, in exceptional circumstances, be lethal. However, the tropical blue-spotted ribbontail ray, like other stingrays, uses its sting just to defend itself. Much of its time is spent resting motionless on sandy patches among coral, hidden under overhangs. Often only its blue-edged tail gives it away to divers—if disturbed, it will swim away, flapping its two winglike pectoral fins. The best time to see one is on a rising tide when the stingrays swim inshore to feed on invertebrates in shallow water.

SIZE 28–35 in (70–90 cm), including tail
HABITAT Sandy patches in coral reefs
DISTRIBUTION Indian Ocean, W. Pacific
DIET Mollusks, crabs, shrimps, worms

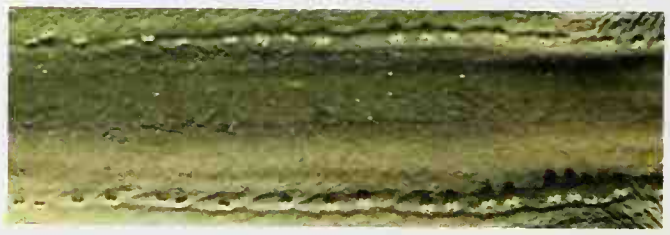
PELVIC FINS >
In this female the urogenital opening is visible between the pelvic fins on the underside. After mating, females produce up to seven live young following a few months' to a year's gestation.



< MOUTH
The mouth is on the underside of the stingray, allowing it to extract mollusks and crabs hidden beneath the surface of the sand. Two plates within the mouth are used to crush the shells of its prey.

< GILL SLITS
After passing over the gills, water leaves the body through five pairs of gill slits on the underside.

v TOP HOLE
Oxygen-rich water is drawn in over the gills through two spiracles on top of the head behind the eyes. Their elevated position helps prevent sand from getting in.



< BACK SPINES
This species has relatively smooth skin, but has two parallel rows of tiny spines running down its back, as well as other scattered spines.

^ ARMED TAIL
The tail is armed with one or two sharp, barbed spines that cause physical wounds and inject venom if the ray is attacked or stepped on.

spiracle behind eye

barbed tail

^ **HIDDEN SPOTS**
Unlike most of its relatives, the blue-spotted ribbontail ray rarely buries itself in sand, relying instead on its camouflage colors. Although bright, its blue spots break up the ray's outline when seen from above in the shifting sunlight of a shallow coral reef.

pectoral fin

mouth

< **THE FLIP SIDE**
The mouth, nostrils, and gill slits are all on the underside. The skin is plain white with no blue spots because this side is usually hidden.

tail spine

pelvic fin

eye

v **FRONT VIEW**
The eyes are raised up on top of the head so that the ray can watch for predators and prey, even when it is partially buried in sand.

RAY-FINNED FISHES

These fishes are bony, with a hard, calcified skeleton. Their fins are supported by a fan of jointed rods called rays, made of bone or cartilage.

Ray-finned fish are able to swim with far greater precision than cartilaginous fish. Using their highly mobile and versatile fins, they can execute maneuvers such as hovering, braking, and even swimming backward. The fins themselves can be delicate and flexible or strong and spiny and they often have important secondary uses, such as in defense, display, and camouflage.

With the exception of bottom-living species, most ray-finned fish have a buoyancy aid in the form of a gas-filled swim bladder. This allows them to maintain their position at a certain depth and to rise or fall by adjusting the pressure of the gas.

MYRIAD ADAPTATIONS

The great majority of fish are ray-finned and the group is hugely diverse—ranging from tiny gobies to the gigantic ocean sunfish. Species have evolved to inhabit every conceivable aquatic niche from tropical coral reefs to the waters beneath the ice-shelves of Antarctica and from the depths of the ocean to shallow desert pools. Herbivores, carnivores, and scavengers are all well represented in the group and its members exhibit many ingenious hunting and defense strategies, as well as cooperation between species.

SAFETY IN NUMBERS

Most ray-finned fish shed eggs and sperm into the water and fertilization is external. In some cases, fewer eggs are laid and parental care is provided. For example, jawfish and some cichlids protect their eggs and young in their mouths, while sticklebacks and many wrasses build nests of weed and debris. Some species protect their eggs with such vigor that even scuba divers are warned off.

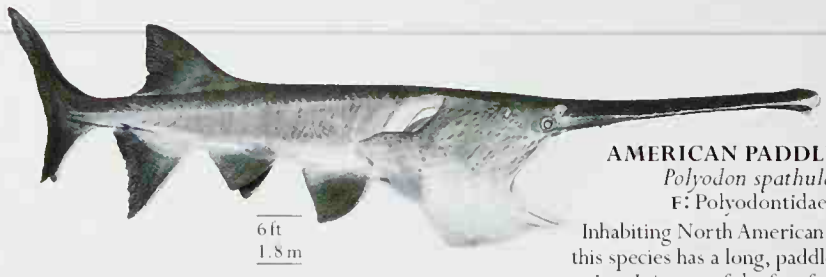
Most species, however, lay eggs in vast numbers. The millions of floating eggs and fish larvae are an important food source for other aquatic creatures, but those that survive drift and disperse the species. Populations of fish reproducing in this way are less vulnerable to overfishing because numbers can recover when fishing stops, but even stocks of such prolific breeders as Atlantic cod will eventually succumb if intense levels of fishing are continued.

PHYLUM	CHORDATA
CLASS	ACTINOPTERYGII
ORDER	46
FAMILIES	482
SPECIES	30,033

A pair of bluecheek butterflyfishes *(Chaetodon semilarvatus)* swim in unison as they patrol their patch of coral reef.

STURGEONS AND RELATIVES

Among the members of the order Acipenseriformes, only the sturgeon family includes marine species. The skull and some fin supports are made of hard bone, but most of the remaining skeleton is made of pliable cartilage. As in sharks, which these fishes resemble, the tail is asymmetrical with a longer upper lobe.



6 ft
1.8 m

AMERICAN PADDLEFISH
Polyodon spathula
F: Polyodontidae

Inhabiting North American wetlands, this species has a long, paddlelike upper jaw. It is one of the few freshwater fishes that feed by straining plankton.

11 ft
3.5 m

EUROPEAN STURGEON
Acipenser sturio
F: Acipenseridae

Heavily protected with rows of bony plates, this critically endangered species, once prized for its caviar, inhabits coastal waters, but swims into rivers to breed.

GARS

Fishes in the order Lepisosteiformes are primitive, freshwater predators in North America, with long, cylindrical bodies, protected by heavy, close-fitting scales. Their long jaws have needlelike teeth.

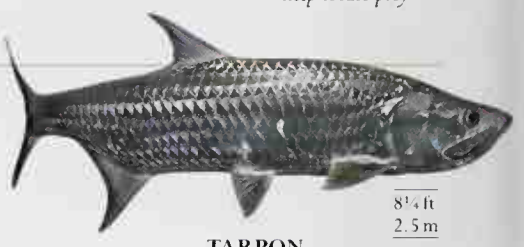
6 ft
1.8 m

LONGNOSE GAR
Lepisosteus osseus
F: Lepisosteidae

A skilled predator, this long, thin fish hangs motionless in the water, hidden by vegetation, before thrusting forward to capture its prey.

TARPONS AND TENPOUNDERS

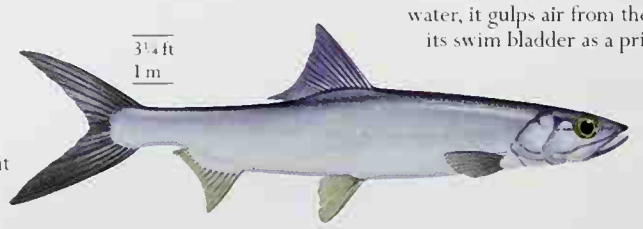
The order Elopiformes is small and its members are silvery with only one dorsal fin and a forked tail. They resemble giant herring. They have special throat bones (gular plates). Although these are marine fishes, some species also swim up estuaries and rivers.



8¼ ft
2.5 m

TARPON
Megalops atlanticus
F: Megalopidae

Found along Atlantic coasts, the tarpon sometimes enters rivers. In stagnant water, it gulps air from the surface using its swim bladder as a primitive lung.



3¼ ft
1 m

LADYFISH
Elops saurus
F: Elopidae

The ladyfish moves in large schools, close to the western Atlantic shores. When alarmed, it skips over the water's surface.

BONYTONGUES AND RELATIVES

As their name suggests, the fishes of the order Osteoglossiformes have many sharp teeth on the tongue and roof of the mouth, which help them seize and hold prey. These fishes live in freshwater, mainly in the tropics. The group has many fishes with unusual shapes.

ARAPAIMA
Arapaima gigas
F: Arapaimidae

Weighing up to 440 lb (200 kg), this South American species is one of the largest freshwater fish. Its long fins help it lunge forward to catch prey.

ELEPHANTNOSE FISH
Gnathonemus petersii
F: Mormyridae

This African fish finds its way in its murky water habitat by generating weak electrical pulses. Its long lower jaw probes the mud for food.

CLOWN KNIFEFISH
Chitala chitala
F: Notopteridae

This slender, humpbacked fish lives in wetlands of southeast Asia. In stagnant water, it gulps air and absorbs oxygen from its swim bladder.

EELS

The Anguilliformes have long, thin, snakelike bodies with smooth skin, in which the scales are either absent or deeply embedded. The fins are often limited to one long fin runing down the back, around the tail and along the belly. Eels are found in marine and freshwater habitats.

ZEBRA MORAY
Gymnomuraena zebra
F: Muraenidae

This tropical, boldly striped eel has dense pebblelike teeth to eat tough-shelled crabs, mollusks, and sea urchins.

JEWEL MORAY EEL
Muraena lentiginosa
F: Muraenidae

Inhabiting coral reefs in the eastern Pacific, this eel rhythmically opens and closes its mouth for respiration.

SPOTTED GARDEN EEL
Heteroconger hassi
F: Congridae

Sandy patches near coral reefs house colonies or "gardens" of this eel. With their tails hidden in burrows, these eels sway like plants, retreating if disturbed.

CONGER EEL
Conger conger
F: Congridae

This eel of the North Atlantic and Mediterranean finds an ideal home in shipwrecks. It hides in crevices during the day, emerging only at night to hunt other fishes.

RIBBON EEL
Rhinomuraena quaesita
F: Muraenidae

Juvenile ribbon eels are black with yellow fins and mature into bright blue males. These later change sex and become yellow females. They are found in the Indian and western Pacific oceans.

EUROPEAN EEL
Anguilla anguilla
F: Anguillidae

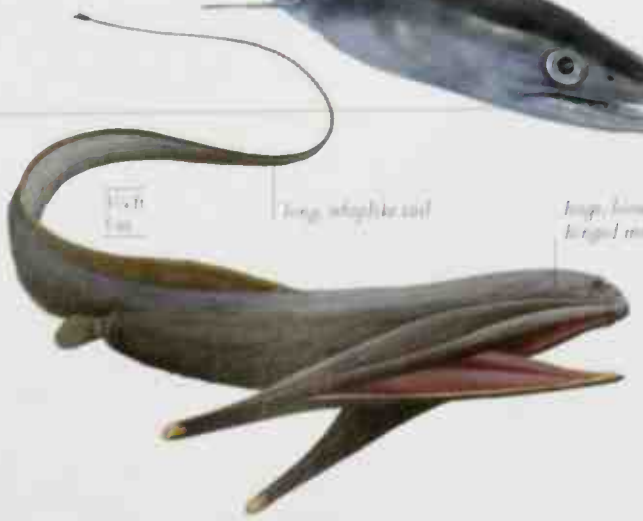
Spending most of its life in freshwater, this endangered, snakelike eel migrates across the Atlantic to the Sargasso Sea to spawn and then die.

BANDED SNAKE EEL
Myrichthys colubrinus
F: Ophichthidae

Closely resembling a venomous sea snake, this harmless eel of the Indian and western Pacific oceans is left alone by predators. It searches in sand burrows for small fishes.

SWALLOWERS AND GULPERS

Living in the deep ocean, these bizarre, eel-like fishes, belonging to the order Saccopharyngiformes, have no tail fin or pelvic fins, and no scales. They do not have ribs and their large jaws are modified for a wide gape. They are believed to spawn once and then die, like true eels.

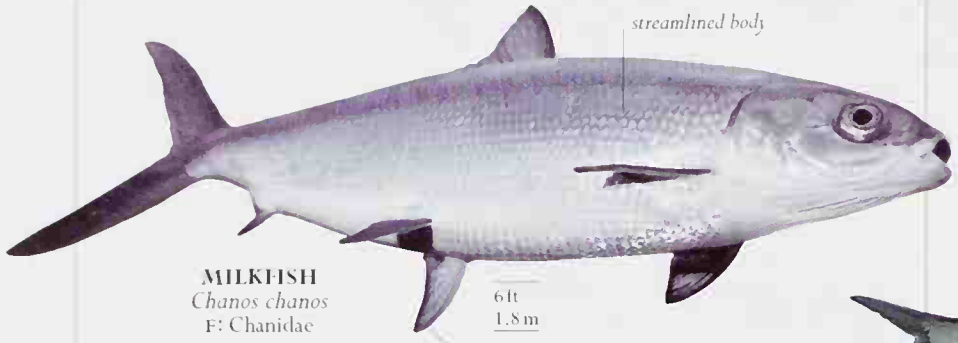


PELICAN GULPER EEL
Eurypharynx pelecanoides
F: Eurypharyngidae

This deep-sea, eel-like fish has huge jaws and an expandable stomach, which enable it to swallow prey almost as large as itself.

MILKFISH AND RELATIVES

With only two exceptions, including the milkfish itself, the Gonorynchiformes live in freshwater. They have a pair of pelvic fins that are set well back on the belly.



MILKFISH
Chanos chanos
F: Chanidae

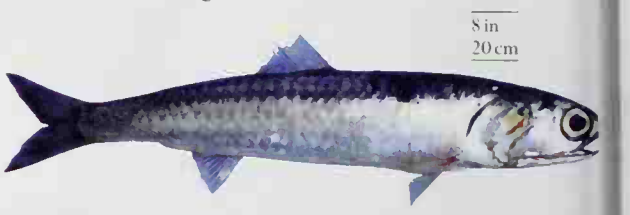
This fast swimmer has a large forked tail. Feeding solely on plankton, it is farmed in southeast Asia.

BEAKED SALMON
Gonorynchus greyi
F: Gonorynchidae

Native to Australia and New Zealand, this fish lives near the seabed and dives under sand if threatened.

SARDINES AND RELATIVES

This predominantly marine order includes many commercially important species. The Clupeiformes are silvery, with loose scales, one dorsal fin, a forked tail, and a keel-shaped belly. Most live in large schools and are preyed on by sharks, tuna, and other large fishes.



PERUVIAN ANCHOVETA
Engraulis ringens
F: Engraulidae

This tiny plankton-eater lives in enormous schools along the western coast of South America, where it is a major source of food for humans, pelicans, and larger fishes.

ALLIS SHAD
Alosa alosa
F: Clupeidae

In spring, adults of this species migrate from the sea into European rivers to spawn, sometimes swimming very long distances.

ATLANTIC HERRING
Clupea harengus
F: Clupeidae

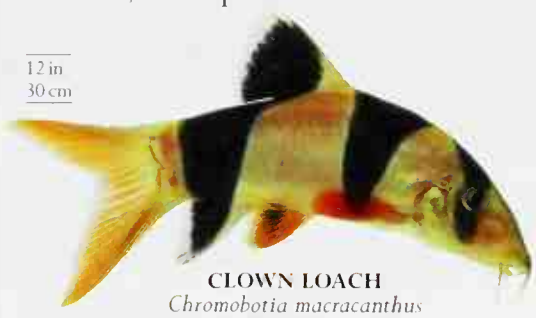
This silver-scaled fish lives in large schools, gathering plankton. Distinct local races exist in the northeast Atlantic and the North Sea.

CARP AND RELATIVES

This is one of the largest freshwater fish orders, with over 3,000 species worldwide. The Cypriniformes have the standard "fish shape," with a single dorsal fin. They typically have large scales. The teeth are in the throat instead of the jaws. Many are familiar aquarium fishes, including loaches, minnows, and carp.

TIGER BARB
Puntius tetrazona
F: Cyprinidae

Native to the Indonesian islands of Sumatra and Borneo, this fish has been widely introduced elsewhere and is bred for the aquarium trade.



CLOWN LOACH
Chromobotia macracanthus
F: Cobitidae

Native to wetlands in southeast Asia, this loach is a bottom-feeder. It has sharp spines by its eyes, which it uses to defend itself.

BITTERLING
Rhodeus amarus
F: Cyprinidae

This European fish lays its eggs inside the mantle cavity of a mussel, where they grow and hatch before the fry swim away.

GRASS CARP
Ctenopharyngodon idella
F: Cyprinidae

A native of Asia, this species feeds on aquatic plants. For this reason, it has been introduced in Europe and the USA to keep drainage channels clear of weeds.

GOLDFISH
Carassius auratus
F: Cyprinidae

Originally native to central Asia and China, the goldfish has been introduced all over the world and there are now many varieties.

COMMON CARP
Cyprinus carpio
F: Cyprinidae

With its mouth that can be thrust out and sensory barbels, a carp finds food by grubbing through the bottom mud. Now introduced worldwide, it was originally from China and central Europe.

ZEBRAFISH
Brachydanio rerio
F: Cyprinidae

This active little fish spawns frequently and is common in ponds and lakes in South Asia. It is bred in aquaria and laboratories.

CHARACINS AND RELATIVES

These freshwater fishes are mostly carnivores, with well-developed teeth. As well as a normal dorsal fin, most also have a small, fatty adipose fin near the tail. Of the 18 families in the order Characiformes, the piranhas are the most notorious predators.

4½ in
12 cm

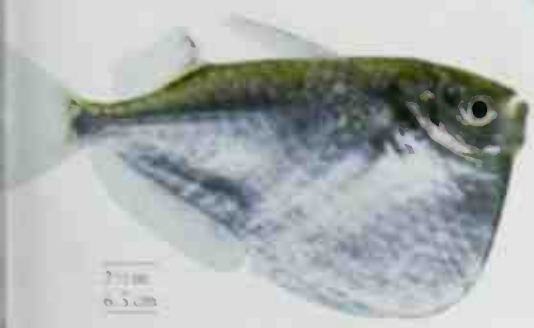
MEXICAN TETRA
Astyanax mexicanus
F: Characidae

While the normal form of the Mexican tetra has sight and lives in streams, its variant lives in cave pools and is blind.

14 in
35 cm

RED PIRANHA
Pygocentrus nattereri
F: Characidae

Native to South American rivers, this fish usually eats invertebrates and fishes, although schools can kill large mammals with their razor-sharp teeth.



7½ in
6.5 cm

RIVER HATCHETFISH
Gasteropelecus sternicla
F: Gasteropelecidae

This insectivorous South American fish has a deep body shape, with powerful muscles that allow it to accelerate rapidly.

3½ ft
1 m

TIGERFISH
Hydrocynus vittatus
F: Alestidae

Native to African rivers, this large predator has fanglike teeth and can eat fishes half as long as itself.

16 in
40 cm

LONGSNOUT DISTICHODUS
Distichodus lusosso
F: Distichodontidae

Unlike some of its piranha relatives, this is a peaceful herbivorous fish. It lives in streams in equatorial Africa.

CATFISHES

The predominantly freshwater catfishes have a long body and many mouth barbels. There is a sharp spine in front of the dorsal and pectoral fins. Most species in the order Siluriformes have a small adipose fin on the back near the tail.

12½ in
32 cm

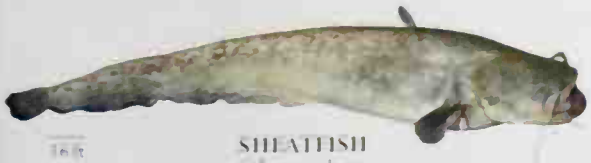
STRIPED EEL CATFISH
Plotosus lineatus
F: Plotosidae

Juveniles of this tropical marine species form dense ball-shaped schools for protection. Solitary adults defend themselves with their venomous fin spines.

3½ ft
1 m

TIGER SHOVELNOSE CATFISH
Pseudoplatystoma fasciatum
F: Pimelodidae

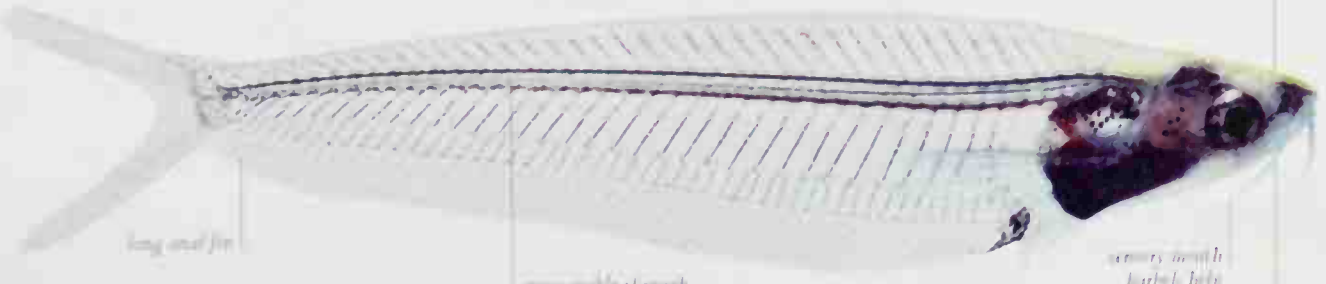
The long barbels of this South American fish help it find food as it hunts over riverbeds at night searching out small fishes.



16 ft
5 m

SHEATFISH
Silurus glanis
F: Siluridae

From wetlands in central Europe and Asia, this huge fish has been known to weigh over 660 lb (300 kg), but due to heavy fishing, none this large exists today.



20½ in
52 cm

BROWN BULLHEAD
Ameiurus nebulosus
F: Ictaluridae

This North American catfish has venomous fin spines that help ward off predators when it is guarding its nest.

6 in
15 cm

GLASS CATFISH
Kryptopterus bicirrhis
F: Siluridae

This native of southeast Asia often hangs motionless in the water; its transparent body makes it hard to see.

SALMON AND RELATIVES

This order of marine and freshwater fishes also includes many anadromous members (moving from sea to fresh water to breed). Powerful predators, the Salmoniformes have a large tail, a single dorsal fin, and a much smaller adipose fin.

SOCKEYE SALMON
Oncorhynchus nerka
F: Salmonidae

From the North Pacific, this fish moves up rivers into Asian and North American lakes to spawn. At this time, both sexes turn red and the male's jaw develops a hook.

hooked jaw on male

CISCO
Coregonus artedi
F: Salmonidae

Widespread in North American lakes and large rivers, this fish forms schools that feed on plankton and invertebrates.

ARCTIC CHAR
Salvelinus alpinus
F: Salmonidae

Clean, cold water is a must for this fish. Some individuals live in high-altitude lakes, while others migrate from sea to river.

RAINBOW TROUT
Oncorhynchus mykiss
F: Salmonidae

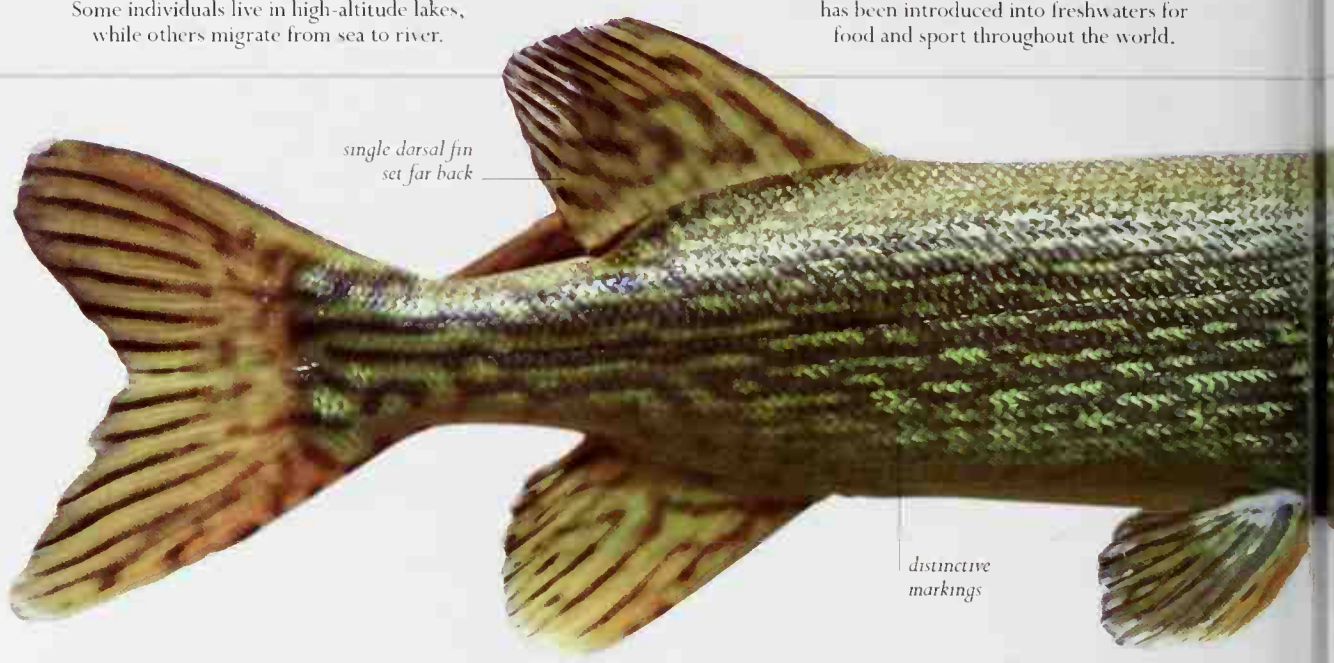
Although native to North America, this fish has been introduced into freshwaters for food and sport throughout the world.

PIKES AND RELATIVES

Found in cool freshwaters across the Northern Hemisphere, the Esociformes are fast and agile. The dorsal and anal fins are set far back, near the tail, to give these predatory fishes an instant forward thrust.

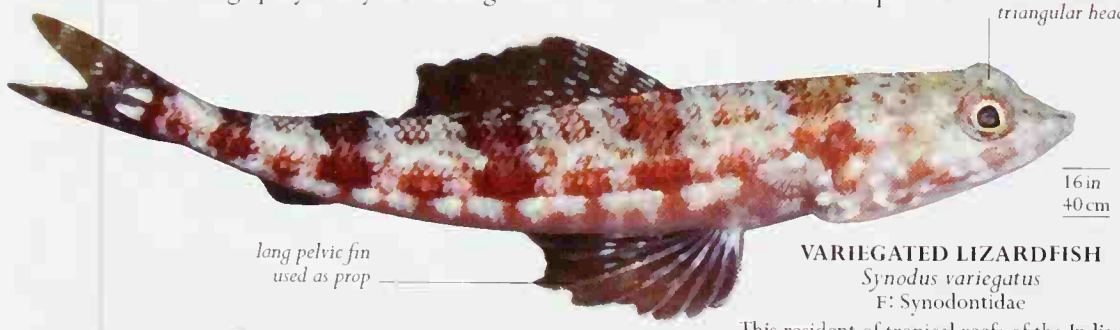
MUD MINNOW
Umbra krameri
F: Umbridae

The European mud minnow is now rare, as the small ditches and canals of its home—the Danube and Dneister river systems—disappear.



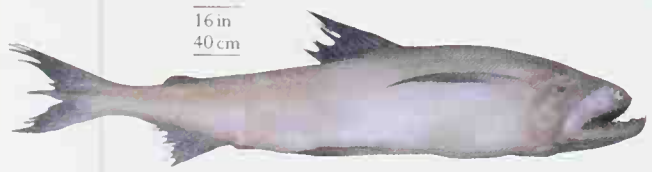
LIZARDFISHES AND RELATIVES

This diverse order of marine fishes inhabits shallow coastal waters as well as the deep sea. The Aulopiformes have large mouths, with many small teeth, and can catch large prey. They have a single dorsal fin and a much smaller adipose fin.



VARIEGATED LIZARDFISH
Synodus variegatus
F: Synodontidae

This resident of tropical reefs of the Indian and Pacific oceans perches on a coral head, remaining completely still, and then darts out to catch fish.



BOMBAY DUCK
Harpadon nehereus
F: Synodontidae

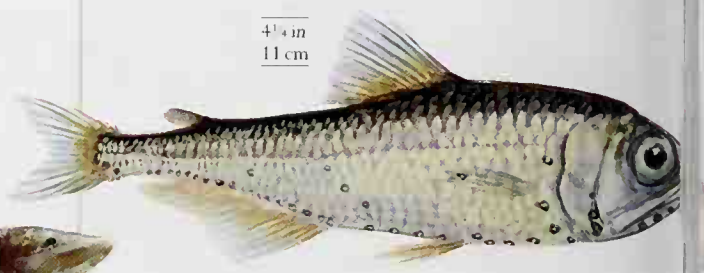
During the monsoon season in the Indo-Pacific, schools of this small fish gather near river deltas to feed on material that is washed down

FEELER FISH
Bathypterois longifilis
F: Ipnopidae

This globally distributed fish perches above the deep, muddy ocean floor, and uses its filament-like pectoral fins to catch food.

LANTERNFISHES AND RELATIVES

Lanternfishes are small, slim fishes with many photophores (light organs) that help them communicate in their deep, dark ocean habitat. Members of the order Myctophiformes, these species have large eyes and many migrate toward the surface at night to feed.



SPOTTED LANTERNFISH
Myctophum punctatum
F: Myctophidae

Living in the depths of the Atlantic, this lanternfish uses its impressive array of light-emitting organs, or photophores, to signal to others.

DRAGONFISHES AND RELATIVES

A majority of these deep-sea fishes have photophores to help them hunt, hide, and find mates. Most members of the order Stomiiformes are fearsome-looking predators, with large teeth and sometimes a long chin barbel.

NORTHERN STOPLIGHT LOOSEJAW
Malacosteus niger
F: Stomiidae

Found globally in temperate, tropical, and subtropical oceans, this fish uses a beam of red bioluminescent light, which its shrimp prey cannot see.

SLOANE'S VIPERFISH
Chauliodus sloani
F: Stomiidae

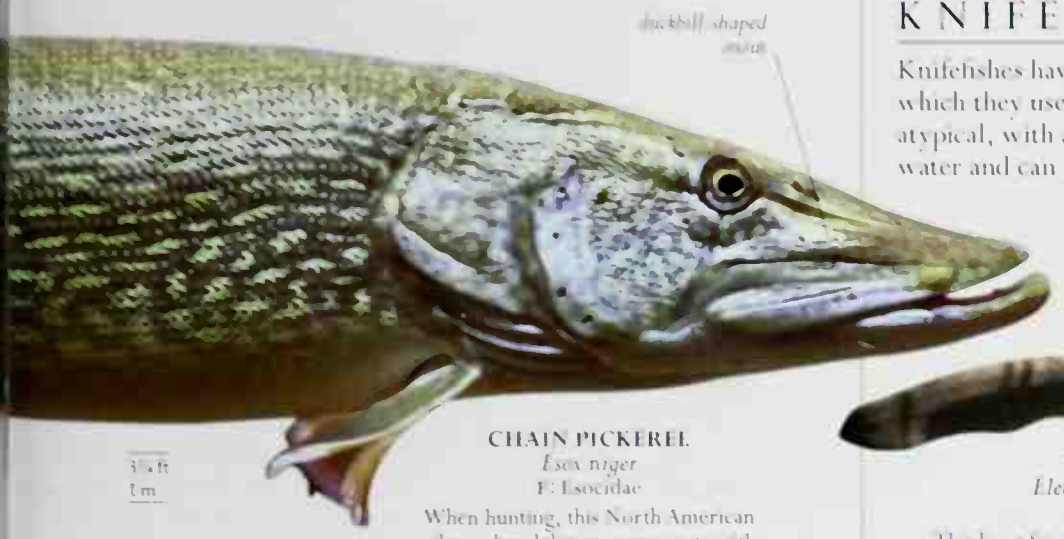
The Sloane's viperfish has long, transparent fangs that protrude when its mouth is closed. It uses photophores to emit light in the depths of tropical and subtropical oceans.

PACIFIC HATCHETFISH
Argyropelecus affinis
F: Sternoptychidae

The silvery, thin body of this fish helps camouflage and hide it from predators. It is found in temperate, tropical, and subtropical waters.

KNIFEFISHES

Knifefishes have flattened, eel-like bodies, and a single long anal fin, which they use to move backward and forward. The electric eel is atypical, with a long, round body. The Gymnotiformes live in fresh water and can produce electrical impulses.



CHAIN PICKEREL
Esox niger
F: Esocidae

When hunting, this North American pike makes delicate movements with its fins to hover motionlessly before striking with lightning speed.

ELECTRIC EEL
Electrophorus electricus
F: Gymnotidae

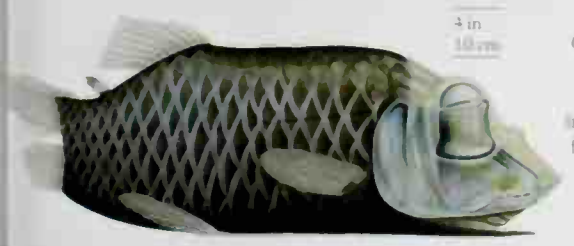
This large South American fish can produce an electric shock of up to 600 volts—enough to kill other fish and stun a human.

BANDED KNIFEFISH
Gymnotus carapo
F: Gymnotidae

Found in murky wetlands in Central and South America, this fish produces mild electric currents, which it uses to sense its surroundings.

SMELTS AND RELATIVES

Smelts resemble small, slim salmon and, like them, most have an adipose fin on the back near the tail. Some of the Osmeriformes have a distinctive smell. The European smelt smells like fresh cucumber.



BARREL-EYE
Opisthoproctus soleatus
F: Opisthoproctidae

Living in semidarkness in oceans worldwide, this fish has tubular eyes that point upward. These help it make full use of the available light.

CAPELIN
Mallotus villosus
F: Osmeridae

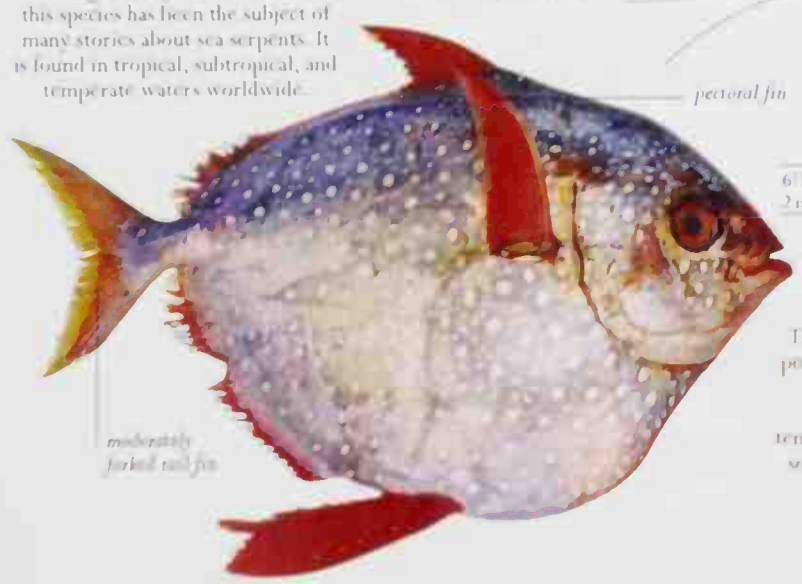
Found in cold Arctic and nearby waters, this fish forms large schools that are a crucial food source for many seabirds; its abundance or scarcity determines the breeding success of these birds.

OARFISHES AND RELATIVES

The 18 members of this marine order, called Lampriformes, are colourful fishes of the open ocean, the adults having crimson fins. In many species, the rays of the dorsal fin extend as long streamers. Most fishes in this order are ocean wanderers that are rarely seen.

OARFISH
Regalecus glesne
F: Regalecidae

The longest bony fish in the world, this species has been the subject of many stories about sea serpents. It is found in tropical, subtropical, and temperate waters worldwide.



OPAH
Lampris guttatus
F: Lampridae

This fish beats its long pectoral fins like wings. Inhabiting tropical, subtropical, and temperate oceans, it eats squid and small fishes.

ANGLERFISHES AND RELATIVES

The 300 or so Lophiiformes include some of the most bizarre of all marine fishes. A modified fin ray on top of the head acts as a fishing lure (bioluminescent in deep-water species), which attracts prey toward the fishes' cavernous mouths.

8 in
20 cm

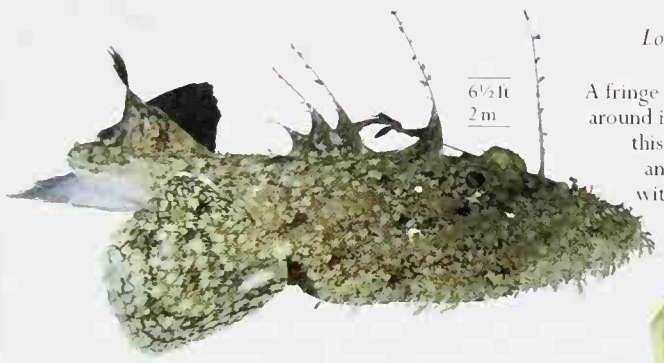
RED-LIPPED BATFISH
Ogcocephalus darwini
F: Ogcocephalidae

The oddly shaped batfish props itself up on its paired pectoral and pelvic fins and shuffles around in search of food.

9 in
22 cm

COFFINFISH
Chaunax endeavouri
F: Chaunacidae

Coffinfishes lie on muddy seabeds in the southwest Pacific, waiting for small fish to stray within reach.



6½ ft
2 m

ANGLER
Lophius piscatorius
F: Lophiidae

A fringe of seaweed-shaped flaps around its mouth helps disguise this northeast Atlantic angler. It can strike with lightning speed.

4½ in
11.5 cm

WARTY FROGFISH
Antennarius maculatus
F: Antennariidae

The well-camouflaged warty frogfish clambers over coral reefs using its limblike pectoral fins.

8 in
20 cm

FANFIN ANGLER
Caulophryne jordani
F: Caulophrynidae

In the dark ocean depths it is difficult to find a mate. Once successful, the tiny male fanfin angler latches onto the female permanently.

8 in
20 cm

skin flaps for camouflage

large pectoral fins used for swimming

SARGASSUMFISH
Histrio histrio
F: Antennariidae

While most frogfish live on the seabed, this one hides among rafts of floating *Sargassum* seaweed, which it closely resembles.

COD AND RELATIVES

The Gadiformes include many important marine commercial species. Most have two or three soft dorsal fins on their back and many have a chin barbel. Grenadiers live in deep water and have a long thin tail.

6½ ft
2 m

chin barbel

ATLANTIC COD
Gadus morhua
F: Gadidae

Overfishing has reduced the average weight of Atlantic cod to 24 lb (11 kg) from a historical maximum weight of over 200 lb (90 kg).

3 ft/91 cm

ALASKA POLLOCK
Theragra chalcogramma
F: Gadidae

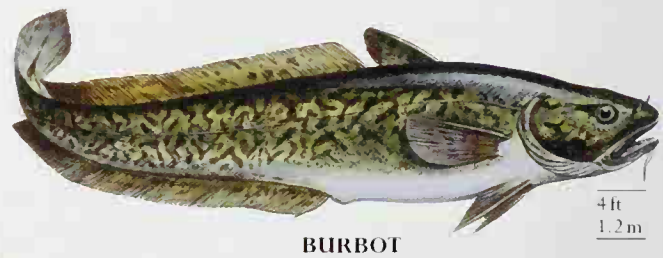
The lack of a chin barbel and a protruding lower jaw help distinguish this fish from cod. It lives in cold Arctic waters.

20 in/50 cm

SHORE ROCKLING
Gaidropsarus mediterraneus
F: Lotidae

Equipped with three sensory mouth barbels, this eel-like rockling searches out food in northeast Atlantic rock pools.

colorful tail fin with rounded edge



4 ft
1.2 m

BURBOT
Lota lota
F: Lotidae

Unlike most of its relatives, the burbot lives in freshwater. It is found in deep lakes and rivers across the Northern Hemisphere.

3¼ ft
1 m

PACIFIC GRENADIER
Coryphaenoides acrolepis
F: Macrouridae

A long scaly tail and bulbous head give this abundant deepwater cod relative its alternative name of Pacific rat-tail.

CUSK EELS

Most members of the order Ophidiiformes live in the ocean and are long, slim, eel-like fishes. They have thin pelvic fins and long dorsal and anal fins, which in many species join onto the tail fin.

PEARLFISH 8 in/ 21 cm
Carapus acus
F: Carapidae
The adult pearlfish finds refuge inside a sea cucumber, entering tail-first through the anus, exiting at night to feed.

GREY MULLETS

Grey mullets are silvery striped fishes with two widely separated dorsal fins; the first has sharp spines, the second has soft rays. Members of the Mugiliformes are distributed worldwide. They are vegetarian, feeding on fine algae and detritus.

30 in
75 cm

GOLDEN GREY MULLET
Liza aurata
F: Mugilidae
Harbours, estuaries, and coastal waters in the northeast Atlantic are all likely haunts of this mullet, which often lives in schools.

TOADFISHES AND RELATIVES

Toadfishes are broad, squat fishes with a wide mouth and eyes on top of the head. They have two dorsal fins, the first short and spiny and the second long and soft. Many species of the Batrachoidiformes, especially the midshipmen, are known for the remarkable way they use their swim bladders to produce sound.

CORAL TOADFISH
Sanopus splendidus
F: Batrachoididae
The rare coral toadfish is only found on reefs, around only one island off the coast of Mexico. It hides under coral and in crevices.

15 in/ 38 cm

PLAINFIN MIDSHIPMAN
Porichthys notatus
F: Batrachoididae
Living on the rocky shores along the west coast of North America, this fish can breathe air when the tide goes out.

SILVERSIDES AND RELATIVES

These small, slim silvery fishes often live in large schools. There are over 300 Atheriniformes, occuring both in marine and freshwater habitats. Most have two dorsal fins, the first of which has flexible spines, and a single anal fin.

4 in/ 10 cm

THREADFIN RAINBOWFISH
Iriatherina werneri
F: Melanotaeniidae
Mature males of this species display to females with their long fins. These fishes live in southeast Asia and northern Australia in weedy freshwaters.

7 in
19 cm

CALIFORNIA GRUNION
Leuresthes tenuis
F: Atherinopsidae
A spawning grunion risks being stranded when it deposits its eggs in sand on the shore during high spring tides.

NEEDLEFISHES AND RELATIVES

With long, thin, rodlike bodies and extended beaklike jaws, these silvery fishes are well camouflaged in the open ocean. Flying fishes—with their large, paired pectoral (side) and pelvic (belly) fins—also belong to this order, the Belontiformes.

3 ft/ 93 cm

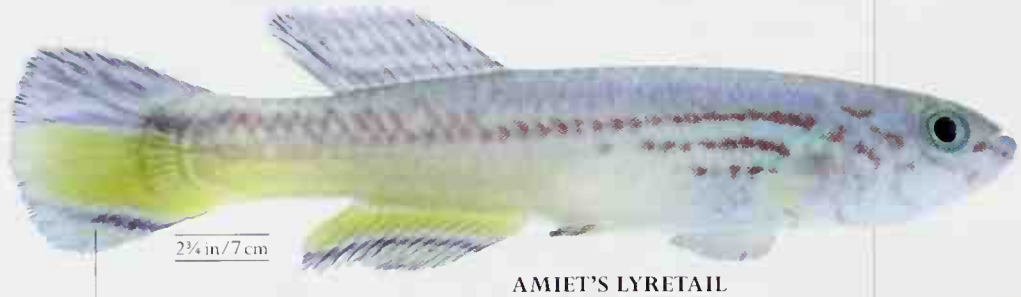
GARFISH
Belone belone
F: Belonidae
Remaining close to the ocean surface in the northeast Atlantic, the needlefish chases small fish, especially members of the herring family.

ATLANTIC FLYINGFISH
Cheilopogon heterurus
F: Exocoetidae
Pursued by predators or startled by boats, this fish escapes by breaching the surface and gliding away on outspread fins.

16 in/ 40 cm

KILLIFISHES AND RELATIVES

Most members of the Cyprinodontiformes are small freshwater fishes with a single dorsal fin and a large tail. Of the ten families, the guppies are perhaps the best known because they produce live young and are popular aquarium fish.



2¾ in/7 cm

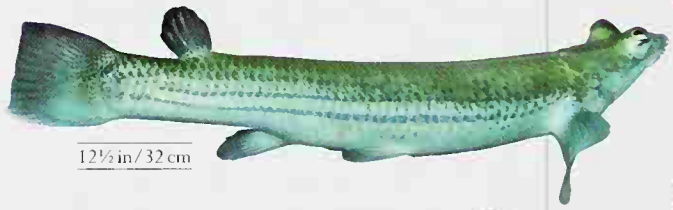
tail important in display

AMIET'S LYRETAIL
Fundulopanchax amieti
F: Nothobranchiidae

This small colorful fish lives in rain forest streams in Cameroon, Africa. There are many other similar species, known collectively as killifishes.

FOUR-EYED FISH
Anableps anableps
F: Anablepidae

The bulging eyes of this South American fish are divided so that it can see clearly both above and below water.



12½ in/32 cm

3 in/7.5 cm

AMERICAN FLAGFISH
Jordanella floridae
F: Cyprinodontidae

Swamps and streams in Florida are home to this peaceful vegetarian. The male courts a female and guards their eggs.

2¾ in/7 cm

BLACK PEARLFISH
Austrolebias nigripinnis
F: Rivulidae

Subtropical rivers in South America are home to this species and all the other members of its colorful family.

2 in/5 cm

SAILFIN MOLLY
Poecilia latipinna
F: Poeciliidae

The large dorsal fin of this North American fish is displayed in courtship. The female bears live young.

SQUIRRELFISHES AND RELATIVES

These marine fishes, in the order Beryciformes, are deep-bodied with large scales, a forked tail, and sharp fin spines. Most are nocturnal and are often a red color. The red end of the light spectrum is the first to be absorbed by water. This makes them appear black below a certain depth.

CROWN SQUIRRELFISH
Sargocentron diadema
F: Holocentridae

This is a typical squirrelfish and one of many similar species found in tropical waters. By day it hides in crevices.

6½ in/17 cm

9 in/22 cm

PINEAPPLEFISH
Cleidopus gloriamaris
F: Monocentridae

Few predators would attack this spiny fish, which has an armor of thick scales. Its color warns that it is unpalatable.

12 cm/4¾ in

EYELIGHT FISH
Photoblepharon palpebratum
F: Anomalopidae

At night this fish signals to others using a light organ under each eye. It has a black membrane that it uses to cover the light, creating a flashing effect.

7 in/18 cm

COMMON FANGTOOTH
Anoplogaster cornuta
F: Anoplogastridae

The huge fangs of this deep-ocean predator make escape impossible for its prey, which it swallows whole.

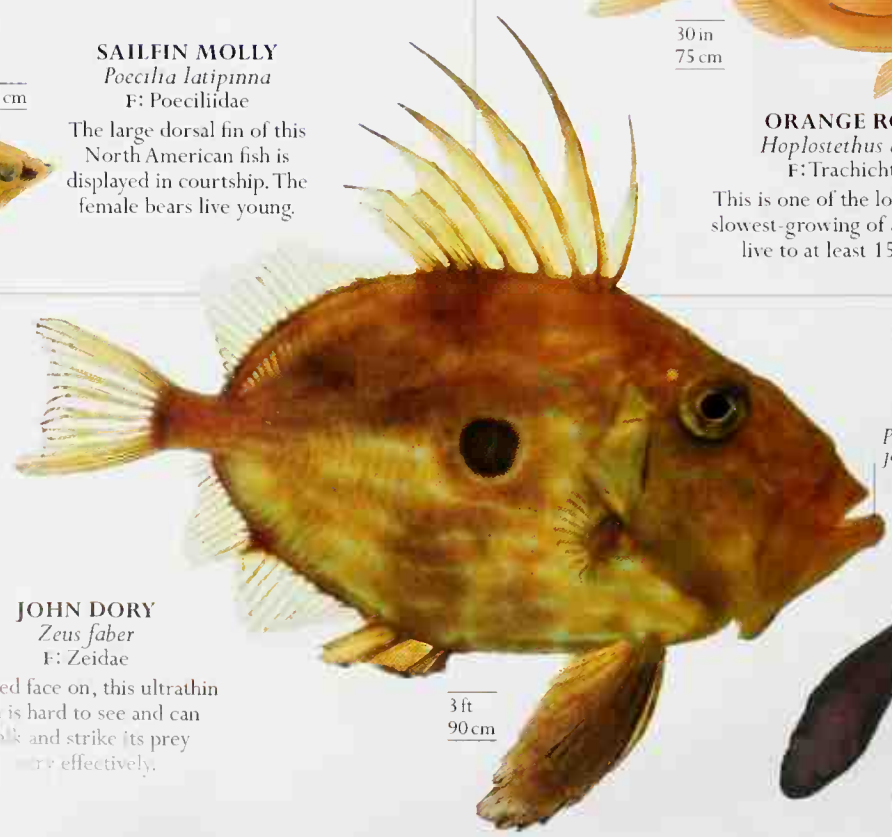
30 in
75 cm

ORANGE ROUGHY
Hoplostethus atlanticus
F: Trachichthyidae

This is one of the longest-lived and slowest-growing of any fish and can live to at least 150 years old.

DORIES AND RELATIVES

The 42 species belonging to the order Zeiformes are all marine, deep-bodied, but thin fishes with long dorsal and anal fins. Dories have protrusible jaws—they can be shot out to capture prey. They feed on a wide range of small fish—that they [illegible]



3 ft
90 cm

protrusible jaw

JOHN DORY
Zeus faber
F: Zeidae

Viewed face on, this ultrathin fish is hard to see and can [illegible] and strike its prey [illegible] effectively.

STICKLEBACKS AND SEAMOTHS

Most sticklebacks inhabit still and slow-moving freshwater, but some live in the sea as do seamoths. The Gasterosteiformes have a long, thin, stiff body protected by bony scutes (plates) along the sides and sharp spines along the back.

THREE-SPINED STICKLEBACK
Gasterosteus aculeatus
F: Gasterosteidae

This little fish is widespread in freshwater and shallow seas in the Northern Hemisphere. The male performs an elaborate courtship dance.

SEAMOTH
Eurypegasus draconis
F: Pegasidae

Unlike the closely related sticklebacks, the tropical marine seamoth is flat and has large winglike pectoral (side) fins.

CLINGFISHES AND RELATIVES

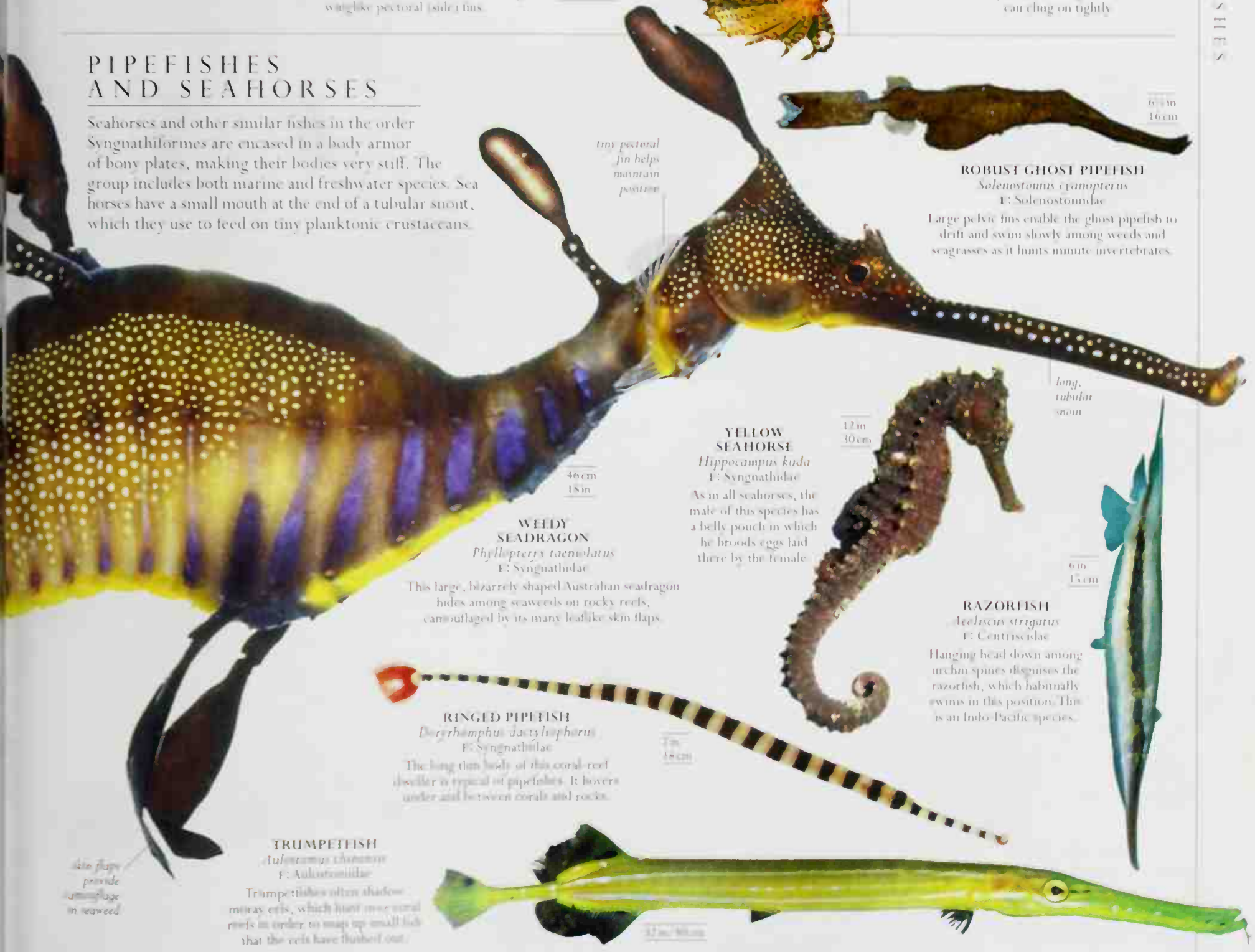
Clingfishes are small, usually marine, bottom-dwelling fishes. Most of the Gobiesociformes possess a sucker formed from modified pelvic fins with which they cling to rocks. Their eyes are set high on the head and they have one dorsal fin.

CONNEMARA CLINGFISH
Lepadogaster candolii
F: Gobiesocidae

Living in rocky shallows in the northeast Atlantic, this little fish is exposed to strong waves, but can cling on tightly.

PIPEFISHES AND SEAHORSES

Seahorses and other similar fishes in the order Syngnathiformes are encased in a body armor of bony plates, making their bodies very stiff. The group includes both marine and freshwater species. Sea horses have a small mouth at the end of a tubular snout, which they use to feed on tiny planktonic crustaceans.



WEEDY SEADRAGON
Phyllopteryx taeniolatus
F: Syngnathidae

This large, bizarrely shaped Australian seadragon hides among seaweeds on rocky reefs, camouflaged by its many leaflike skin flaps.

RINGED PIPEFISH
Dorsthamphus dactylophorus
F: Syngnathidae

The long thin body of this coral-reef dweller is typical of pipefishes. It hovers under and between corals and rocks.

TRUMPETFISH
Aulostomus chinensis
F: Aulostomidae

Trumpetfishes often shadow moray eels, which hunt over coral reefs in order to snap up small fish that the eels have flushed out.

ROBUST GHOST PIPEFISH
Solenostomus cyanopterus
F: Solenostomidae

Large pelvic fins enable the ghost pipefish to drift and swim slowly among weeds and seagrasses as it hunts minute invertebrates.

YELLOW SEAHORSE
Hippocampus kuda
F: Syngnathidae

As in all seahorses, the male of this species has a belly pouch in which he broods eggs laid there by the female.

RAZORFISH
Aeoliscus strigatus
F: Centriscidae

Hanging head down among urchin spines disguises the razorfish, which habitually swims in this position. This is an Indo-Pacific species.

SWAMPEELS AND RELATIVES

These tropical and subtropical freshwater fishes have an eel-like body and no pelvic fins. Other fins are often reduced as well. A few of the Synbranchiformes survive in brackish water such as mangrove swamps.

3¼ ft
1 m

FIRE EEL
Mastacembelus erythrotaenia
F: Mastacembelidae

Living in flooded lowland plains and slow rivers in southeast Asia, this edible spiny eel eats insect larvae and worms.

MARBLED SWAMPEEL
Synbranchus marmoratus
F: Synbranchidae

Able to breathe air if necessary, this almost finless fish lives in small bodies of water in Central and South America.

5 ft
1.5 m

FLATFISHES

Pleuronectiformes start life as normal juveniles with a left and a right side but as they grow the body becomes flattened and they lie on the seabed. The underneath eye migrates round to join the other on the upper side.

3¼ ft
1 m

EUROPEAN PLAICE
Pleuronectes platessa
F: Pleuronectidae

This important North Atlantic commercial flatfish lies camouflaged on the sea bed with its right side uppermost. It emerges at night to feed.

8¼ ft
2.5 m

ATLANTIC HALIBUT
Hippoglossus hippoglossus
F: Pleuronectidae

One of the largest flatfish, the Atlantic halibut lies on its left side with both eyes on the upward-facing right side.

28 in
70 cm

COMMON SOLE
Solea solea
F: Soleidae

Although sole can live to 30 years old, most do not survive this long because they are a valuable commercial fish.

3¼ ft
1 m

TURBOT
Psetta maxima
F: Scophthalmidae

The ability to alter its color to match the seabed allows turbot to escape predators' attention. It lives in the North Atlantic.

TRIGGERFISHES, PUFFERFISHES, AND RELATIVES

This diverse group of marine and freshwater fishes includes the huge ocean sunfish and the poisonous pufferfish. Instead of normal teeth, the Tetraodontiformes have fused tooth plates or just a few large teeth. Their scales are modified to form protective spines or plates.

20 in
50 cm

CLOWN TRIGGERFISH
Balistoides conspicillum
F: Balistidae

This brightly colored coral-reef fish can wedge itself in a crevice by erecting its dorsal spines, which lock in position.

10 in
25 cm

SPOTTED BOXFISH
Ostracion meleagris
F: Ostraciidae

Encased in a rigid box of fused bony plates, and with poisonous skin, this Indo-Pacific reef fish is left well alone by predators.

6 in
15 cm

WHITE-SPOTTED PUFFER
Arothron hispidus
F: Tetraodontidae

The neurotoxin contained within the skin and organs of this fish can easily kill a human and deters natural predators.

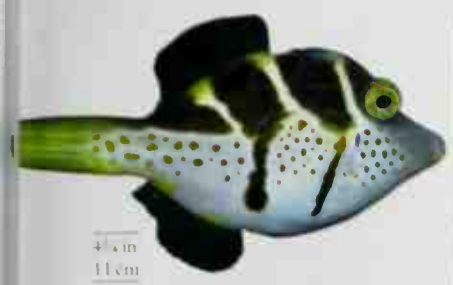
20 in / 50 cm

LONG-SPINE PORCUPINEFISH
Diodon holocanthus
F: Diodontidae

Found in all tropical seas, this spiny fish can suck in water to inflate its body and turn itself into a prickly ball—a very effective deterrent against predators.

SCORPIONFISHES AND RELATIVES

Mostly bottom-living and marine, fishes in this large order have a large spiny head with a unique bony strut across the cheek. Most Scorpaeniformes have sharp, sometimes venomous spines in their dorsal fins and many are camouflage experts.



4¾ in
11 cm

MIMIC FILEFISH
Paraluteres prionurus
F: Monacanthidae

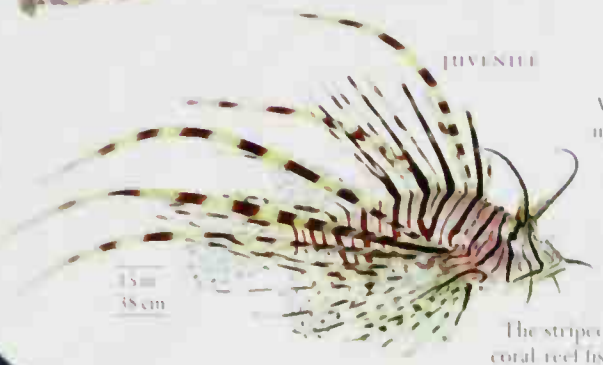
The mimic filefish is avoided by predators because it closely resembles the saddled pufferfish, which has toxic flesh.

14 ¾in
37 cm

SMALLSCALED SCORPIONFISH
Scorpaena porcus
F: Scorpaenidae

Well concealed by skin flaps on the head and its ability to change color, the scorpionfish is hard to spot.

flat back forms top of bony protective box



JUVENILE

15 in
38 cm

RED LIONFISH
Pterois volitans
F: Scorpaenidae

The striped colors warn predators that this coral-reef fish has venomous dorsal fin spines. Adults are less white and may have white spots on their sides.

30 in
75 cm

TUB GURNARD
Chelidonichthys lucerna
F: Triglidae

Walking over the seabed on three mobile rays on each of its pectoral fins, the tub gurnard can probe for hidden invertebrates.

2¾–3 in
60 cm

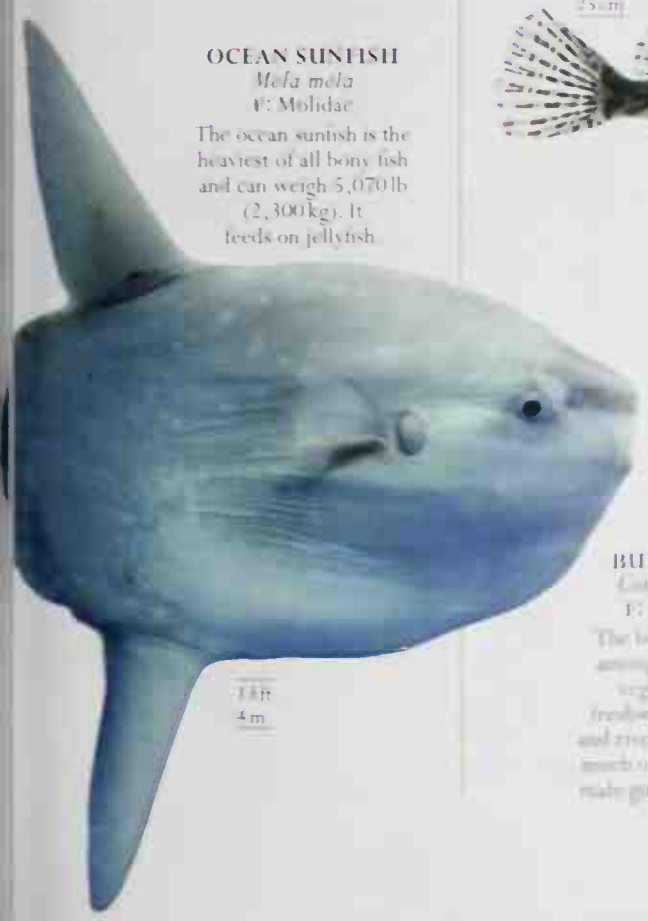
LUMPSUCKER
Cyclopterus lumpus
F: Cyclopteridae

A strong sucker on the belly allows this rotund North Atlantic fish to cling onto wave-battered rocks and guard its eggs.

8¼ in
21 cm

BIG BAIKAL OILFISH
Comephorus baikalensis
F: Comephoridae

About a quarter of the body of this fish is oil, which provides it with buoyancy. It is endemic to Lake Baikal, Russia.



OCEAN SUNFISH
Mola mola
F: Molidae

The ocean sunfish is the heaviest of all bony fish and can weigh 5,070 lb (2,300 kg). It feeds on jellyfish.

13 ft
4 m

10 in
25 cm

LONGSPINED BULLHEAD
Taurulus bubalis
F: Cottidae

The color of this shallow coastal fish varies widely, according to its background. For example, fish living among red seaweeds are red.

small mouth has stout teeth to tear off sponges

venomous dorsal fin spines

large, upturned mouth

STONEFISH
Synanceia verrucosa
F: Synanceiidae

It is extremely difficult to spot this well-camouflaged tropical reef fish. A sting from its venomous spines can be fatal to humans.

16 in
40 cm

3 in/7.8 cm

BULLHEAD
Cottus gobio
F: Cottidae

The bullhead lives among stones and vegetation in freshwater streams and rivers throughout much of Europe. The male guards the eggs.

20 in
50 cm

FLYING GURNARD
Dactylopterus volitans
F: Dactylopteridae

This species uses its huge fanlike pectoral fins to "fly" through the water. It "takes off" from the seabed if disturbed.

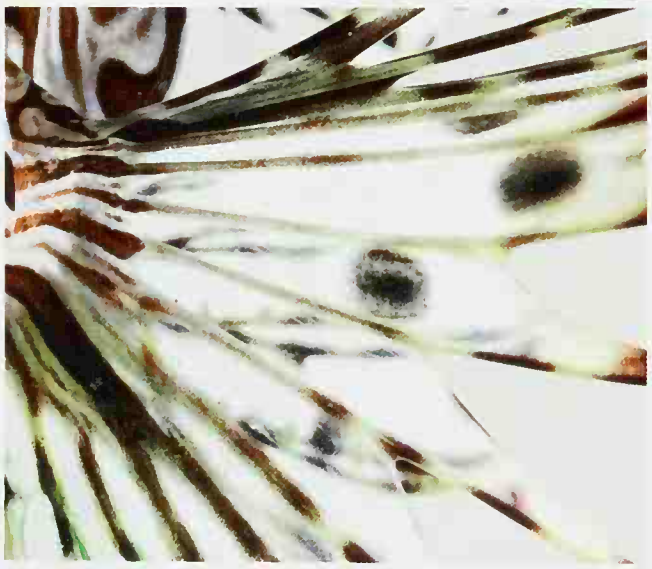
RED LIONFISH
Pterois volitans

The red lionfish is a night hunter, patrolling tropical coral and rocky reefs in the western Pacific in search of small fish and crustaceans. It corrals its prey against the reef by spreading out its wide pectoral fins—one on each side of its body—before snapping up the prey with lightning speed. Sometimes it stalks its prey out in the open, relying on stealth and a final quick rush, similar to a lion hunting on an African plain. Protected by venomous spines, it will often face a diver or potential predator head-on if approached. One male may collect a small harem of females and will charge other males that stray too close. When ready to spawn, the male displays to the female, circling around her before they swim up toward the surface to shed eggs and sperm into the water. After a few days the eggs hatch into planktonic larvae that drift in the plankton for about a month before settling on the seabed.

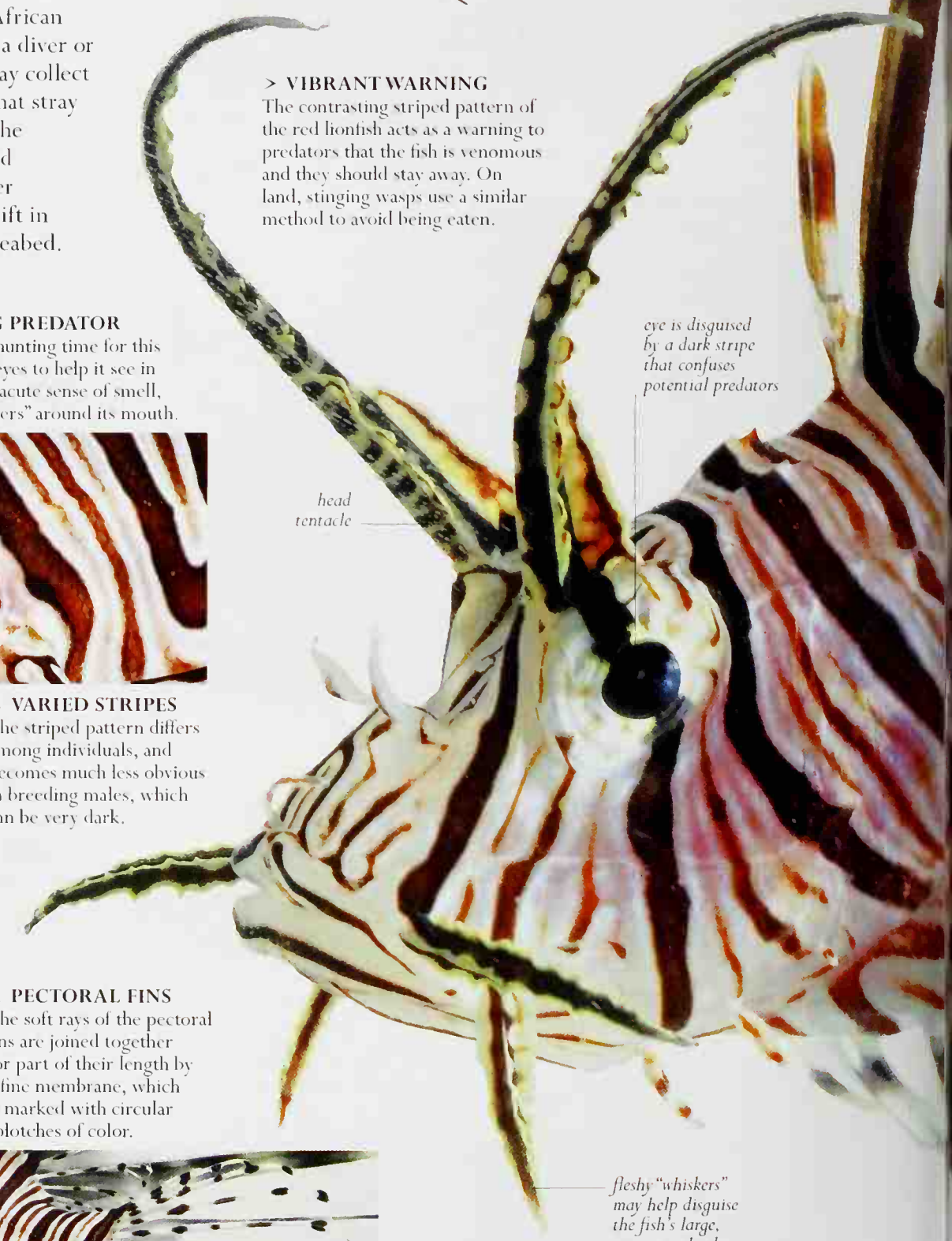
SIZE 15 in (38 cm) in length
HABITAT Coral and rock reefs
DISTRIBUTION Pacific Ocean, introduced into W. Atlantic
DIET Fish and crustaceans

> VIBRANT WARNING
The contrasting striped pattern of the red lionfish acts as a warning to predators that the fish is venomous and they should stay away. On land, stinging wasps use a similar method to avoid being eaten.

< MENACING PREDATOR
Dusk is a prime hunting time for this fish. It has large eyes to help it see in the dim light, an acute sense of smell, and fleshy "whiskers" around its mouth.



^ VARIED STRIPES
The striped pattern differs among individuals, and becomes much less obvious in breeding males, which can be very dark.


head tentacle
eye is disguised by a dark stripe that confuses potential predators
fleshy "whiskers" may help disguise the fish's large, open mouth when approaching prey

< PECTORAL FINS
The soft rays of the pectoral fins are joined together for part of their length by a fine membrane, which is marked with circular splotches of color.

VENOMOUS SPINES >
Sharp spines in this fish's dorsal, anal, and pelvic fins can be used to inject venom that causes extreme pain in humans, but is rarely fatal. The spines are purely defensive.

< TAIL UP
Lionfish normally hang slightly head down and tail up, ready to pounce on passing prey. The tail helps the fish maintain this position, rather than to swim fast.

dorsal fin made up of several spines
wide rays of pectoral fins spread out fully when the lionfish ambushes prey
tail
anal fin

PERCH AND RELATIVES

With 156 families and nearly 10,000 species, the Perciformes form the largest and most diverse vertebrate order. At first sight, there seems little to connect some of these fishes, but they all have a similar anatomy. Most have both spines and soft rays in their dorsal and anal fins. The pelvic fins are set well forward, close to the pectoral fins.

23½ in
60 cm

LONGFIN SPADEFISH
Platax teira
F: Ephippidae

Living on coral reefs in the Indo-Pacific, this flattened species patrols in small groups, feeding on algae and invertebrates.

6½ in
16 cm

FOURSPOT BUTTERFLYFISH
Chaetodon quadrimaculatus
F: Chaetodontidae

Many different species of butterflyfishes are found on coral reefs around the world. This fish lives in the western Pacific.

35 in
90 cm

BLUE-SPOTTED SEABREAM
Pagrus caeruleostictus
F: Sparidae

Found in the eastern Atlantic, this is a typical seabream with a steep head profile, forked tail, and long dorsal fin.

4¾ in
12 cm

OCHRE-STRIPED CARDINALFISH
Apogon compressus
F: Apogonidae

This coral-reef resident of the western Pacific is a small, nocturnal species with two dorsal fins and large eyes. The male incubates the eggs in his mouth.

32 in
80 cm

RED BANDFISH
Cepola macrophthalma
F: Cepolidae

Living in vertical mud burrows in the northeast Atlantic, the red bandfish feeds on passing plankton.

16 in
40 cm

RED MULLET
Mullus surmuletus
F: Mullidae

Common in the Mediterranean and northeast Atlantic, this species detects buried prey with its mobile barbels. It is a relative of the tropical goatfish.

12 in
30 cm

GREEN SUNFISH
Lepomis cyanellus
F: Centrarchidae

Well known in North America, this large species is one of the most common fishes in lakes and rivers.

12 in
30 cm

BANDED ARCHERFISH
Toxotes jaculatrix
F: Toxotidae

Living mainly in brackish mangrove estuaries in southeast Asia, Australia, and the western Pacific, it catches insects from overhanging branches by shooting a jet of water from its mouth.

juvenile has brown body with black-edged white spots

28 in
72 cm

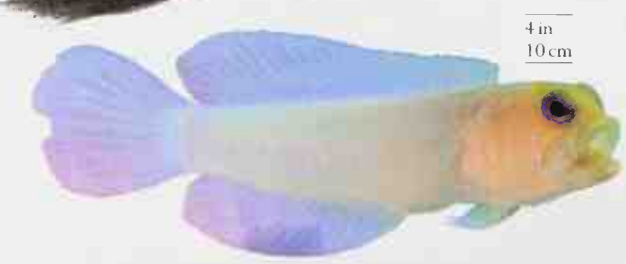
HARLEQUIN SWEETLIPS
Plectorhinchus chaetodonoides
F: Haemulidae

The adult harlequin sweetlips is cream with black spots. The color and movement of the juvenile mimics a toxic flatworm.

4 ft
1.2 m

BLUEFISH
Pomatomus saltatrix
F: Pomatomidae

This widespread, voracious, and aggressive predator roams tropical and subtropical oceans in schools that herd and attack smaller fish.



4 in
10 cm

YELLOWHEAD JAWFISH
Opistognathus aurifrons
F: Opistognathidae

After the female of this Caribbean fish has laid her eggs, the male broods them in his mouth.

20 in
51 cm

EUROPEAN PERCH
Perca fluviatilis
F: Percidae

Native to Europe and Asia, this widespread, predatory freshwater fish has been introduced as a sport fish for anglers in Australia and elsewhere, where it has become a pest.

16 in
40 cm

EMPEROR ANGELFISH
Pomacanthus imperator
F: Pomacanthidae

This species lives on coral reefs in the Indo-Pacific. Juveniles and adults have different patterns, which protects juveniles from territorial aggression by adults.

10 in
25 cm

ROYAL ANGELFISH
Pygoplites diacanthus
F: Pomacanthidae

The striking colors of the royal angelfish and of other coral reef fishes aid recognition and communication between species.

38 in
70 cm

HUMPBACK GROUPER
Cromileptes altivelis
F: Serranidae

Like most other groupers, this Indo-Pacific coral reef species changes sex from female to male as it matures.

4 in
10 cm

AMAZON LEAFFISH
Monocirrhus polyacanthus
F: Polycentridae

With its large mouth and habit of drifting like a dead leaf, this South American freshwater predator can quickly engulf unsuspecting prey.

6½ ft
2 m

WRECKFISH
Polyprion americanus
F: Polyprionidae

Young wreckfish live a nomadic life among surface-drifting debris, while the adults prefer shipwrecks, caves, and rocky areas. They are found throughout the world's oceans.

10 in
25 cm

SILVER MOONY
Monodactylus argenteus
F: Monodactylidae

This flattened Indo-Pacific species is most at home in brackish water estuaries, where it swims in small schools.

6 in
15 cm

SEA GOLDIE
Pseudanthias squampinnis
F: Serranidae

This small fish gathers plankton from the waters near steep coral cliffs and ledges. The males defend a harem of females.

28 in
70 cm

BROWN MEAGRE
Sciaena umbra
F: Sciaenidae

Belonging to a family known as drums and croakers, this fish of the northeast Atlantic and Mediterranean communicates with loud sounds from its swim bladder.

8½ ft
2.5 m

GIANT GROUPER
Epinephelus lanceolatus
F: Serranidae

The largest of all groupers, this massive fish can weigh up to 880 lb (400 kg). It inhabits Indo-Pacific coral reefs, but is now rare as a result of heavy fishing.

10 in
25 cm

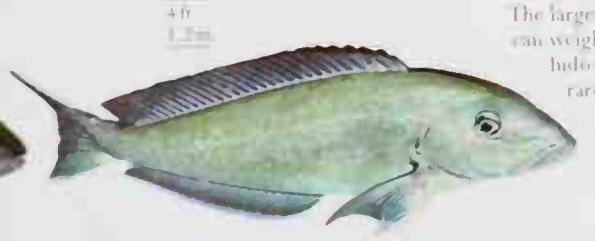
JACK-KNIFEFISH
Equetus lanceolatus
F: Sciaenidae

Deep coral reefs in the tropical western Atlantic are home to this unusually shaped fish. Its shape and color provide camouflage.

16 in
40 cm

COMMON BLUESTRIPE SNAPPER
Lutjanus kasmira
F: Lutjanidae

This fast-swimming snapper forms schools in coral reefs during the day, dispersing at night to feed.



4 ft
1.2 m

GRAY TILEFISH
Caulolatilus microps
F: Malacanthidae

Living in mud and sand off the east coast of North America, it mostly remains within a depth of 655 ft (200 m) to avoid very cold water.

»

8 in
20 cm

SMALL SANDEEL
Ammodytes tobianus
F: Ammodytidae

This small silvery species is a vital food source for seabirds. It is found in large schools in shallow sandy bays of the northeast Atlantic Ocean.

5 ft
1.5 m

WOLF-FISH
Anarhichas lupus
F: Anarhichadidae

A large mouth and strong teeth enable this North Atlantic species to tackle hard-shelled invertebrates.

6 in
15 cm

LESSER WEEVERFISH
Echiichthys vipera
F: Trachinidae

This venomous northeast Atlantic fish lies buried in the sand and can inflict a painful sting from its spiny, black, first dorsal fin.

BLACK SWALLOWER
Chiasmodon niger
F: Chiasmodontidae

Found in deep tropical and subtropical waters, where food is scarce, this fish, with its huge mouth and distendable stomach, can tackle prey larger than itself.

10 in
25 cm

16 in
40 cm

CUCKOO WRASSE
Labrus mixtus
F: Labridae

Males of this species are blue and orange, while females are pink. Some females change color and sex, and become male. It is found in the northeast Atlantic and Mediterranean.

10 in
25 cm

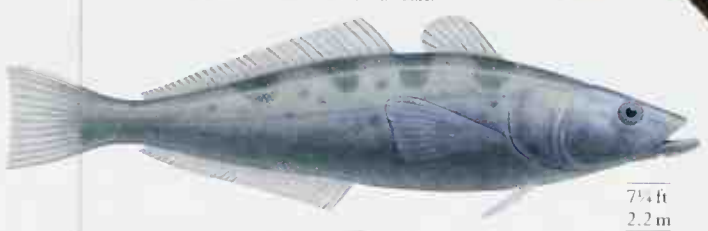
HARLEQUIN TUSKFISH
Choerodon fasciatus
F: Labridae

This member of the wrasse family from the western Pacific uses its protruding canine-like teeth to move stones in its search for invertebrate prey.

CLEANER WRASSE
Labroides dimidiatus
F: Labridae

This tiny wrasse forms a mutualistic relationship with other reef fishes. It cleans and eats parasites off these fishes at specially set up "cleaner stations" on the reef.

5½ in
14 cm



7¾ ft
2.2 m

ANTARCTIC TOOTHFISH
Dissostichus mawsoni
F: Nototheniidae

Like many Southern Ocean fishes, this species grows slowly, eventually reaching a large size. Its blood contains natural antifreeze, which helps it survive icy waters.

15 in
38 cm

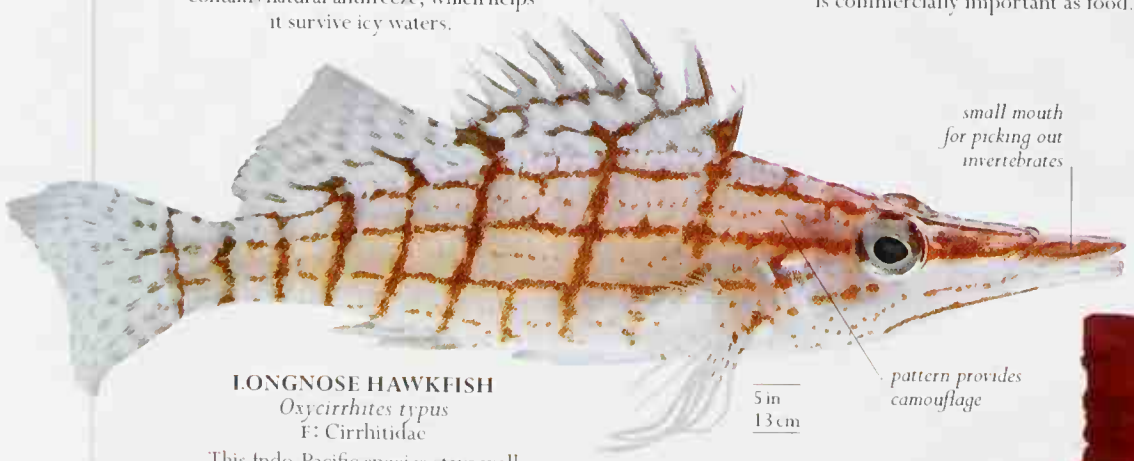
MAORI COD
Paranotothenia magellanica
F: Nototheniidae

Found as far north as New Zealand and Argentina, this Southern Ocean species is commercially important as food.

7 ft
2.1 m

DOLPHINFISH
Coryphaena hippurus
F: Coryphaenidae

This fast predator of the open ocean can reach a speed of 37 mph (60 kph). It is found worldwide in warm waters.



5 in
13 cm

LONGNOSE HAWKFISH
Oxycirrhites typus
F: Cirrhitidae

This Indo-Pacific species stays well camouflaged among sea fans and black corals, where it preys on small invertebrates.

3¼ ft
1 m

SHARKSUCKER
Echeneis naucrates
F: Echeneidae

This species has a ridged sucker on top of its head that allows it to cling onto large fishes, dolphins, and turtles. It benefits from scraps as its host feeds.

BIGEYE TREVALLY
Caranx sexfasciatus
F: Carangidae

Built for speed, this predator hunts other fishes at night over reefs in the Indian and Pacific oceans. Juveniles live inshore and may enter estuaries.

white stripes with thin black outline

4¾ in
11 cm

CLOWN ANEMONEFISH
Amphiprion ocellaris
F: Pomacentridae

Protected by a special slime, this colorful fish of the tropical western Pacific finds a safe home among the stinging tentacles of giant sea anemones.

9 in
23 cm

BLUE CHROMIS
Chromis cyanea
F: Pomacentridae

Found in the tropical western Atlantic, this is one of the most common fishes on coral reefs. It lays its eggs through an orange breeding tube.

6 in
15 cm

SERGEANT MAJOR
Abudefduf saxatilis
F: Pomacentridae

The most common member of the damselfish family, this brightly striped, small fish can be easily spotted on coral reefs in the Atlantic Ocean.

single long dorsal fin

19 in
49 cm

TILAPIA
Oreochromis niloticus edwardianus
F: Cichlidae

This common subspecies of African lakes is a locally important source of food. The female broods about 2,000 eggs in her mouth.

JUVENILE

5 in
13 cm

CHIPOKAE
Melanochromis chipokae
F: Cichlidae

This species is found only around the rocky shores of Lake Malawi in Africa. Other fishes in this family are endemic to other lakes.

2½ in
6.5 cm

ORCHID DOTTYBACK
Pseudochromis fridmani
F: Pseudochromidae

One of the most brightly colored species of all coral-reef fishes, this Red Sea denizen hides beneath overhangs in steep areas.

4 in
10 cm

CONVICT CICHLID
Amatitlania nigrofasciata
F: Cichlidae

Native to C. American rivers and streams, this cichlid has been introduced elsewhere and is a potential pest competing for food and space.

6 in
15 cm

FRESHWATER ANGELFISH
Pterophyllum scalare
F: Cichlidae

This musnal cichlid, with its disklike and laterally compressed body, is native to South American swamps. Both parents guard the eggs and fry.

elongated pelvic fin

30 in
75 cm

COMMON STARGAZER
Kathetostoma laeve
F: Uranoscopidae

Found around southern Australia, the common stargazer buries itself in sand with just its eyes and mouth exposed.

10 in
25 cm

GUNNEL
Pholis gunnellus
F: Pholidae

Found in rocky pools in the North Atlantic, this eel-like fish with no scales can be very slippery, sliding away easily from predators.

bump helps break up coral

growth solid-like marking

28 in
72 cm

BLACKFIN ICEFISH
Chaenocephalus aceratus
F: Channichthyidae

A natural antifreeze in the blood of this Southern Ocean fish enables it to survive at temperatures as low as 28.4°F (−2°C).

beaklike teeth

20 in
50 cm

MEDITERRANEAN PARROTFISH
Sparisoma cretense
F: Scaridae

This Mediterranean species is the only parrotfish in which the female is more colorful than the male. Most other parrotfish species are tropical.

4½ in
1.3 in

GREEN HUMPHEAD PARROTFISH
Bolbometopon muricatum
F: Scaridae

A tough beaklike mouth allows this Indo-Pacific coral reef resident to crunch up living coral, expelling the remains as sand.

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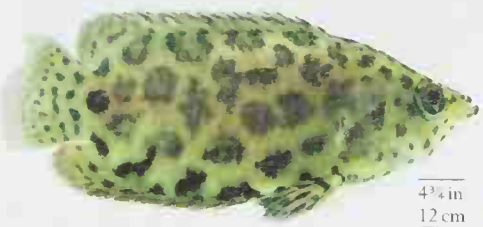
» PERCH AND RELATIVES



4¾ in
12 cm

SPOTTED CTENOPOMA
Ctenopoma acutirostre
F: Anabantidae

This tropical freshwater fish is found in the Congo basin of Africa. It often stalks its prey with its head held down.

2½ in
6.5 cm

SIAMESE FIGHTING FISH
Betta splendens
F: Osphronemidae

The original range of this Asian freshwater fish is unclear, but it has been bred for centuries for its fighting ability, particularly strong in males.

9 in
23 cm

POWDERBLUE SURGEONFISH
Acanthurus leucosternon
F: Acanthuridae

This Indian Ocean fish has a sharp bladelike structure hidden on either side of its tail base, with which it can slash its opponent if attacked.

8 in
20 cm

BUTTERFLY BLENNY
Blennius ocellaris
F: Blenniidae

Like many of its relatives, this fish of the northeast Atlantic lives on the sea bed and guards its eggs, which are often laid in an empty shell.

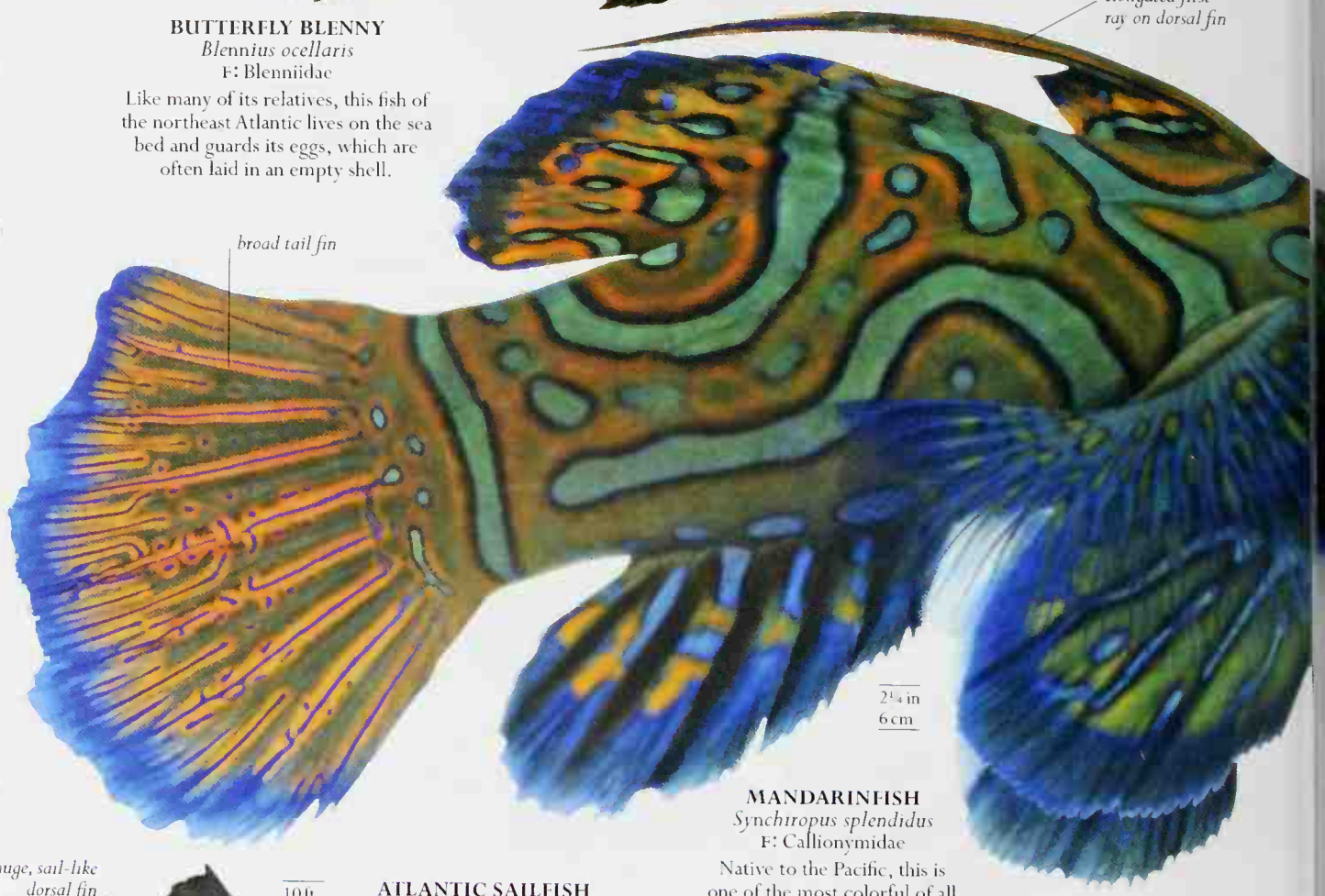
3½ in
9 cm

FIREFISH
Nemateleotris magnifica
F: Microdesmidae

Hovering above its coral reef burrow, this fish gathers plankton from the water and darts back into safety if it senses danger.

elongated first ray on dorsal fin

broad tail fin



2¼ in
6 cm

MANDARINFISH
Synchiropus splendidus
F: Callionymidae

Native to the Pacific, this is one of the most colorful of all tropical reef fish. Its vivid colors warn predators of its foul taste.

huge, sail-like dorsal fin

10 ft
3.2 m

ATLANTIC SAILFISH
Istiophorus albicans
F: Istiophoridae

This ocean predator uses its upper jaw, which extends as a long spear, to slash into schools of fishes and stun them.

spear-shaped snout

torpedo-shaped body

projecting lower jaw

6½ ft
2 m

GREAT BARRACUDA
Sphyraena barracuda
F: Sphyraenidae

Found globally in tropical and subtropical waters, this solitary predator stalks its prey and then accelerates rapidly as it strikes.

23½ in
60 cm

ATLANTIC MACKEREL
Scomber scombrus
F: Scombridae

Living in large schools in the North Atlantic, this fish feeds voraciously on small fishes and plankton. Its streamlined body makes it a fast swimmer.

1½ in
4 cm

BUMBLEBEE FISH
Brachygobius doriae
F: Gobiidae

Found in southeast Asia, this bottom-dwelling goby is tolerant of brackish water and lives in estuaries and mangroves.

3½ in
9 cm

SAND GOBY
Pomatoschistus minutus
F: Gobiidae

This fish is common in sandy inshore areas of the northeast Atlantic. During breeding, males develop a spot at the rear of the first dorsal fin.

15 ft
4.5 m

NORTHERN BLUEFIN TUNA
Thunnus thynnus
F: Scombridae

Found globally, this tuna is one of the world's most valuable commercial fishes. A fast, dynamic predator, it feeds mainly on small fishes.

high-set, bulbous eyes

long tail

10 in
25 cm

ATLANTIC MUDSKIPPER
Periophthalmus barbarus
F: Gobiidae

As long as it stays moist, this mudskipper can stay out of water for hours by absorbing oxygen through its skin.

LOBE-FINNED FISHES

Considered to be the ancestors of land vertebrates, lobe-finned fishes have fins that resemble primitive limbs, with a fleshy base preceding the fin membrane.

Like the ray-finned fishes, these are bony fishes with a hard skeleton but their fins have a different structure. The fin membrane is supported on a muscular lobe that projects out from the body and is strong enough to let some of these fish shuffle along on their paired pectoral and pelvic fins. Bones and cartilage inside the lobes provide attachment for muscles. There are many fossil groups of lobe-finned fishes but living representatives are confined to the marine coelacanths and the freshwater lungfish.

A LIVING FOSSIL

Coelacanths are nocturnal and secretive. The first modern specimen was discovered in 1938—until then only fossil species over 65 million years old were known. The historic find belonged to a species living in deep rocky areas in the western Indian Ocean. A second species was found in Indonesian waters in 1998. The formation of the backbone from the notochord is incomplete and the tail fin has a characteristic extra middle lobe. Their scales are heavy bony plates and they are not long-distance swimmers. Unlike the egg-laying lungfish, coelacanths bear live young because the eggs hatch internally. Gestation may be as long as three years, longer than any other vertebrate, and this makes their survival precarious if individuals continue to be caught in the nets of deep-sea trawlers.

BREATHING OUT OF WATER

Although most of their fossil ancestors lived in the ocean, modern lungfishes are limited to freshwater habitats in South America, Africa, and Australia. All can to some extent breathe air via a connection to the swim bladder—useful when pools dry out seasonally. Some species can survive buried in mud for many months and would die if kept permanently submerged in water, while others still rely mainly on gills for breathing. Their shape and the fact that the larvae of some species have external gills led early zoologists to believe that lungfishes were amphibians.

PHYLUM	CHORDATA
CLASS	SARCOPTERYGII
ORDER	3
FAMILIES	4
SPECIES	8

DEBATE

FISH ON LAND

While it is generally accepted that land-living vertebrates evolved from a fishlike ancestor in the sea, finding that ancestor is more difficult. Recent work suggests that coelacanths and lungfishes (lobe-finned fishes) are more closely related to tetrapods (four-limbed vertebrates such as mammals) than to other fish groups such as sharks. Modern classifications group lobe-finned fishes with tetrapods in the same group, the Sarcopterygii. So coelacanths are not the direct ancestors of tetrapods but a side branch. In 2002 a fossil lobe-finned fish, *Styloichthys*, was found in China. It appears to show close links between lungfishes and tetrapods.

AFRICAN LUNGFISHES

All four species of African lungfishes have a long body and threadlike pectoral and pelvic fins, collectively called paired fins. The Lepidosireniformes breathe through a pair of lungs derived from their swim bladder.

6½ ft
2 m

WEST AFRICAN LUNGFISH
Protopterus annectens
F: Protopteridae

When the lakes in which it lives dry out, this lungfish survives by burying itself in mud, forming a cocoon with an inlet for air.

AUSTRALIAN LUNGFISH

The single species in the order Ceratodontiformes has a long body, large scales, paddle-like paired fins, and a tapering tail. It can breathe through its lungs for short periods, but cannot survive if its habitat dries out.

4 ft
1.3 m

AUSTRALIAN LUNGFISH
Neoceratodus forsteri
F: Ceratodontidae

Living in deep pools and rivers, this lungfish can survive in stagnant water by gulping air into its swim bladder.

COELACANTHS

The two primitive fishes from the order Coelacanthiformes have limblike fleshy bases on their pectoral and pelvic fins, and large bony scales. Other members of their group have been extinct for over 65 million years. In life, these fish are a metallic blue with pale spots, but the color fades on death.

4½ ft
1.4 m

INDONESIAN COELACANTH
Latimeria menadoensis
F: Latimeriidae

Molecular studies have shown this to be a separate species from the coelacanth, although they are physically similar. It lives in the Celebes Sea.

COELACANTH
Latimeria chalumnae
F: Latimeriidae

This fish lives off the coasts of southern Africa and Madagascar in steep, rocky, underwater terrain and hides in deep ocean caves at night.

AMPHIBIANS

Amphibians are cold-blooded vertebrates that thrive in freshwater habitats. Some spend their whole lives in water; others just require water to breed. On land, they must find damp places because their skin is permeable and does not protect them from drying out.

PHYLUM	CHORDATA
CLASS	AMPHIBIA
ORDERS	3
FAMILIES	54
SPECIES	About 6,670

Large numbers of male and female Costa Rican golden toads gathered in a pool to mate. The species is now extinct.

A female of the North American Jefferson's salamander attaches a mass of eggs to a submerged twig in early spring.

In this species of poison frog, *Ranitomeya reticulata*, parents carry tadpoles from one small pool to another.

DEBATE

OUR BIGGEST CHALLENGE?

A third of the world's amphibians face extinction in the near future and this poses a huge conservation challenge. This danger of extinction is largely due to the destruction and pollution of freshwater habitats, but amphibians are also threatened by the global spread of the disease chytridiomycosis, caused by a fungus that attacks their soft skin.

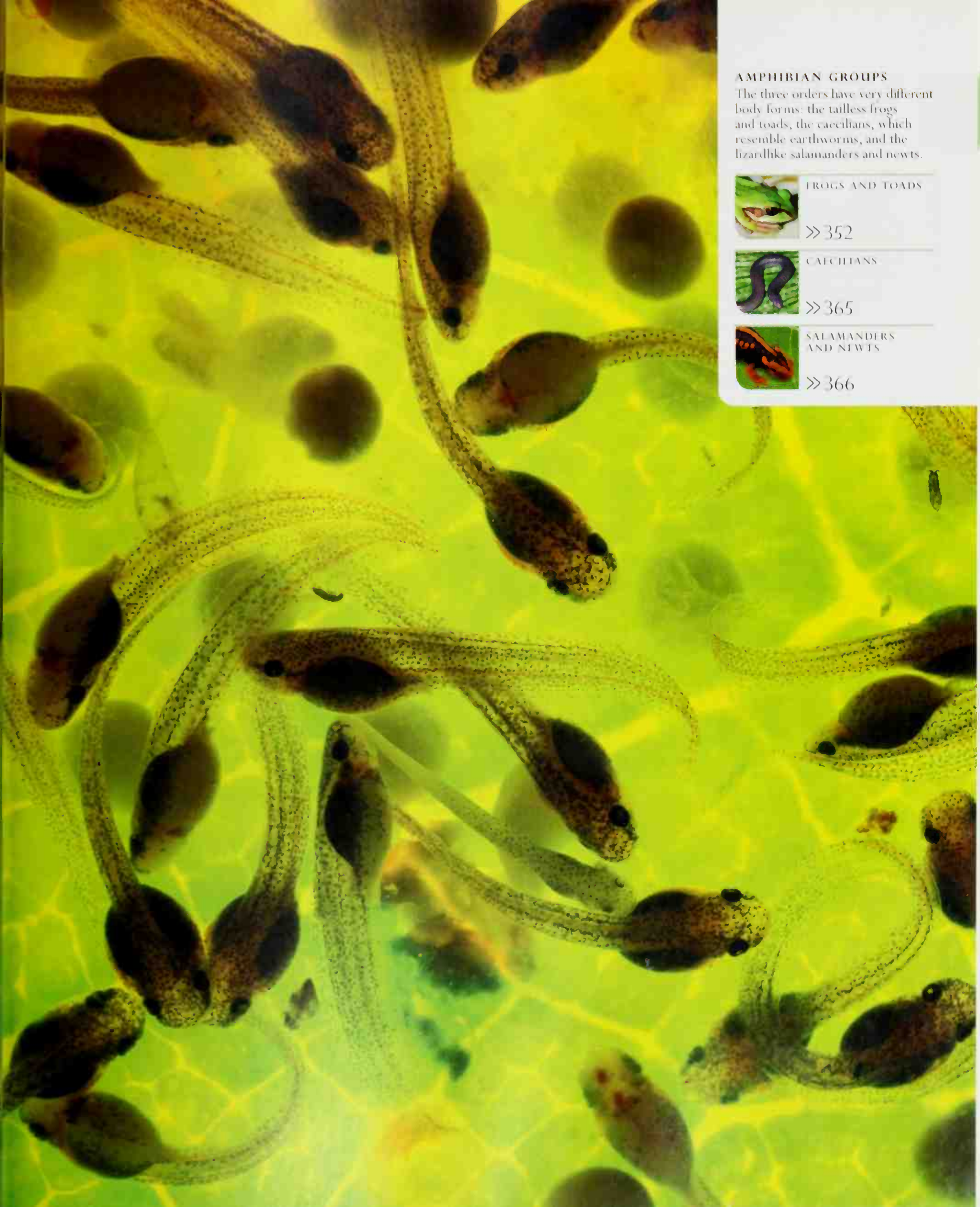
The three orders of living amphibians are thought to share a common ancestor, but their origins are still uncertain. There is a huge gap in the fossil record between the first land animals to evolve from fish—the tetrapods, some 375 million years ago—and a froglike creature that lived 230 million years ago.

Amphibians have a unique and complex life cycle and occupy very different ecological niches at different stages of their lives. Their eggs hatch into larvae—called tadpoles in frogs and toads—that live in water, often in very high densities, and feed on algae and other plant material. As larvae, they grow rapidly and then undergo a complete change of form—metamorphosis—to become land-living adults. As adults, all amphibians are carnivores, most feeding on insects and other small invertebrates. They typically lead secretive and solitary lives, except when they return to ponds and streams to breed. Amphibians thus require two very different habitats during their lives: water and land. During metamorphosis, they undergo a wide variety of anatomical and physiological changes—from aquatic creatures that swim with tails and breathe through gills, to terrestrial animals that move with four limbs and breathe through lungs.

DIVERSE PARENTAL CARE

Some amphibians produce huge numbers of eggs that are left to fend for themselves, so that only a very few will survive. Many others have evolved various forms of parental care. This is generally associated with the production of far fewer offspring, so that reproductive success is achieved by caring for a manageable number of young, rather than by producing as many eggs as possible. Parental care takes many forms, including defending eggs or larvae against predators, feeding tadpoles with unfertilized eggs, and carrying tadpoles from one place to another. In some species, such as the midwife toads and some poison frogs, parental care is the duty of the father. In many salamanders and caecilians, the mother is the sole protector of the young. In a few frog species, mother and father establish a durable pair bond and share parental duties.

READY TO HATCH >
Tadpoles of the Tanzanian Mitchell's reed frog wriggle within their egg membranes, just prior to hatching



AMPHIBIAN GROUPS

The three orders have very different body forms: the tailless frogs and toads, the caecilians, which resemble earthworms, and the lizardlike salamanders and newts.

FROGS AND TOADS

» 352

CAECILIANS

» 365

SALAMANDERS AND NEWTS

» 366

FROGS AND TOADS

With powerful hind limbs tucked under its body, a wide mouth, and protruding eyes, the typical frog has a unique and unmistakable body shape.

The name of the order of frogs and toads, Anura means "animals without a tail." As adults, all other amphibians have tails, but in the anurans, the tail gradually disappears during metamorphosis from the larval to the adult stage of the life cycle. The larvae, known as tadpoles, feed chiefly on plant material and have a spherical body that contains the long, coiled gut required by such a diet. The adults, in contrast, are totally carnivorous, feeding on a wide range of insects and other invertebrates, with larger species also taking small reptiles and mammals, as well as other frogs.

INGENIOUS ADAPTATIONS

Frogs and toads catch their prey by ambush, most spectacularly by jumping. In many frogs and toads, the hind limbs are modified for jumping, being much longer than the forelimbs and very muscular. Jumping is also an effective method of escaping from predators, of which frogs and toads have many. Not all anurans jump, however. Many have hind limbs adapted for other kinds of locomotion, including swimming, burrowing, climbing, and, in a few species, gliding through the air. Most frogs and toads live in damp habitats, close to the pools and streams in which they breed, but there are several species adapted to life in very arid areas. The greatest diversity of anurans is found in the tropics, particularly in rain forests. Many are active by day, while others are nocturnal. Some species are cleverly camouflaged; in contrast, others are brightly colored, advertising that they are poisonous or unpleasant to taste.

COURTSHIP AND BREEDING

Anurans differ from other amphibians in having a voice and very good hearing. Males of most species call to attract females, making sounds characteristic of their species. In all but a very few species, fertilization is external, the male shedding sperm onto the eggs as they emerge from the female's body. To do this, the male clasps the female from above—a position known as amplexus. The duration of amplexus varies between species—from a few minutes to several days.

PHYLUM	CHORDATA
CLASS	AMPHIBIA
ORDER	ANURA
FAMILIES	38
SPECIES	5891

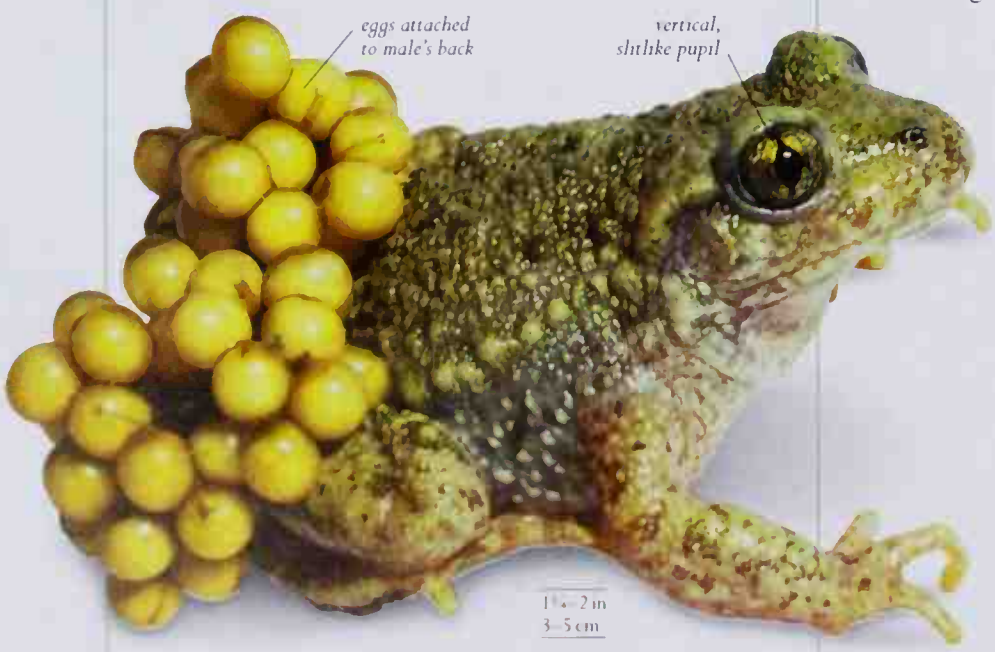
DEBATE

FROG OR TOAD

The distinction between frogs and "toads" is biologically meaningless and the two words are used differently in different parts of the world. In Europe and North America, for example, the term "toad" refers to species in the family Bufonidae, but this includes the South American harlequin frogs. In general, toads have rough skins, are slow-moving, and often burrow in the ground, whereas frogs are smooth-skinned, agile, and fast-moving, and spend much of their time in water. A group of smooth-skinned, aquatic frogs native to much of Africa were once known as clawed toads, but are now called clawed frogs.

MIDWIFE TOADS

Males of the Alytidae, a small family of terrestrial frogs, call at night to attract females. When mating, the male attaches fertilized eggs to his back. He carries them until they are ready to hatch, when he releases the tadpoles into water. Occasionally, a male may carry egg strings from more than one female.



MIDWIFE TOAD
Alytes obstetricans
Found across much of mainland Europe, the midwife toad has a plump body and powerful forelimbs adapted for digging. It hides in a burrow by day.

SQUEAKERS AND RELATIVES

The Arthroleptidae are a large, diverse family of frogs occurring across sub-Saharan Africa—in forest, woodland, and grassland, some at high altitudes. Its members range from tiny "squeakers," named for their high-pitched call, to large tree frogs.

RIO BENITO LONG-FINGERED FROG
Cardioglossa gracilis
An inhabitant of lowland forest, this frog breeds in streams. Males call from nearby slopes.

WEST AFRICAN SCREECHING FROG
Arthroleptis poecilonotus
The female of this small species lays large eggs in soil cavities. The male is noted for his loud call.

WEST CAMEROON FOREST TREE FROG
Leptopelis nordequatorialis
This large tree frog lives in montane grasslands of West Africa. Males call to females near water when breeding, and eggs are deposited in ponds or marshes.

AFRICAN TREE FROG
Leptopelis modestus
This species is found near streams in forests of West and Central Africa. Females are larger than males.

GLASS FROGS

Found in Central and South America, frogs of the family Centrolenidae are known as "glass frogs" because many species have transparent skin on the underside, through which their internal organs are visible.

¾–1¼ in
2–3 cm

FLEISCHMANN'S GLASS FROG
Hyalinobatrachium fleischmanni
Males of this species are territorial, using calls to defend their territory and to attract females. The females lay eggs on leaves over water.

¾–1¼ in
2–3 cm

WHITE-SPOTTED COCHRAN FROG
Sachatamia albomaculata
This species is found in wet lowland forests, and breeds near streams. Males call to females from low vegetation nearby.

1–1¼ in
2.5–3.5 cm

LEMON GIANT GLASS FROG
Sachatamia ilex
This arboreal frog lives in wet vegetation near streams. It has dark green bones, visible through its skin.

¾–1¼ in
2–3 cm

EMERALD GLASS FROG
Espadarana prosoblepon
Males of this arboreal frog are fiercely territorial, defending their space by calling, and occasionally fighting rivals while hanging upside down.

CERATOPHRYIDAE

These South American horned frogs have very large heads and wide mouths that enable them to eat animals nearly as large as themselves. They are "sit-and-wait" predators, remaining still and well-camouflaged before their prey comes within range.

3½–5½ in
9–14 cm

ORNATE HORNED FROG
Ceratophrys ornata
A voracious predator living in grasslands in Argentina, this species breeds after heavy rain, in temporary pools and ditches.

3½–5 in
8–13 cm

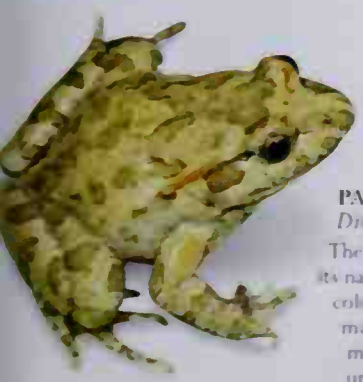
CRANWELL'S HORNED FROG
Ceratophrys cranwelli
Spending much of its life underground, this large frog emerges after heavy rain to mate and lay its eggs in pools.

1½–4 in
4–10 cm

BUDGETT'S FROG
Lepidobatrachus laevis
This frog has a flattened body, a wide mouth, and fangs. It spends dry periods in a cocoon below ground, emerging to breed after rain.

PAINTED FROGS

Confined to Europe and northwest Africa, the Discoglossidae emerge at night from burrows, which they build by digging head first. In some species, the female calls in response to a male's call.



2½–2¾ in
6–7 cm

PAINTED FROG
Discoglossus pictus
The painted frog gets its name from its bright coloration. A female mates with several males, producing up to 1,000 eggs.

ROBBER FROGS

Found in North, Central, and South America, the Craugastoridae produce eggs that develop directly into small adults, without a tadpole stage. Eggs may be deposited on the ground or in vegetation. Many species show parental care of the eggs.

1–2¼ in
2.5–5.5 cm

FITZINGER'S ROBBER FROG
Craugastor fitzingeri
In this forest species, the male calls to the larger female from an elevated perch. Eggs are laid in the ground and are guarded by the female.

1¼–2¾ in
3–7 cm

BROAD-HEADED RAIN FROG
Craugastor megacephalus
This Central American frog hides in a burrow by day and emerges at night. It lays its eggs in leaf litter.

¾–2 in
2–5 cm

ISLA BONITA ROBBER FROG
Craugastor crassidigitus
Native to the humid forests of Central America, this ground-living frog is also found in coffee plantations and pasture.

TRUE TOADS

Distributed worldwide, the family Bufonidae is large and diverse. Its members are characterized by shortened forelimbs, hind limbs that are used for walking or hopping, dry warty skin, and parotoid glands behind the eyes. However, this family also includes the more slender and long-limbed harlequin toads of South America.

horizontal pupil

green blotches on back

warty skin

3½–4¾ in
9–12 cm

GREEN TOAD
Pseudepidalea viridis
A native of sandy habitats, this colorful toad is found in Europe and western Asia. It emerges from its burrow in spring to breed in ponds.

RAUCOUS TOAD
Amietophrynus rangeri
Common in southern Africa, this thickset toad breeds in dams and ponds. Males produce rasping, ducklike calls to attract females.

2–4½ in
5–11.5 cm

2–4 in
5–10 cm

MALAYAN TREE TOAD
Pedostibes hosii
Found in eastern Asia, this toad is unusual in living a largely arboreal life. It has adhesive pads on its toes that enable it to climb trees.

2–4 in
5–10 cm

NATTERJACK
Epidalea calamita
Compared with other true toads, this species has short legs and runs like a mouse. Occurring across Europe, it breeds from spring to summer.

CERATOBATRACHIDAE

Found in Southeast Asia, China, and several Pacific islands, frogs of this family produce large eggs that hatch directly into small frogs. In many species, the tips of the fingers and toes are enlarged.

FIJI GROUND FROG
Platymantis vitianus
The populations of this species on several of the Fijian Islands have been wiped out following the introduction of mongooses.

1–4¼ in
2.5–11 cm

hornlike projection above eye

flat, triangular head

2–3¼ in
5–8 cm

SOLOMON ISLANDS HORNED FROG
Ceratobatrachus guentheri
This species has a pointed snout and hornlike projections above its eyes. It hides among dead leaves.

BOMBINATORIDAE

These small aquatic toads are found in Europe and Asia. They have flattened bodies and many are brightly colored. Fire-bellied toads are active by day, but the dull-colored barbourulas from the Philippines and Borneo are nocturnal.

prominent eyes

bright red underside

bright green coloration

1¼–2 in
3–5 cm

ORIENTAL FIRE-BELLIED TOAD
Bombina orientalis
Found in China and Korea, this small, squat frog can produce a toxic skin secretion. If attacked, it displays its bright belly colors.

RAIN FROGS

Members of the family Brevicipitidae are found in eastern and southern Africa. During mating, the much smaller male is glued onto a female's back by a special skin secretion.

1¼–2 in
3–5 cm

DESERT RAIN FROG
Breviceps macrops
Living away from standing water, this burrowing frog lives and breeds among Namibian sand dunes, occasionally moistened by sea fog.

2–3½ in
5–9 cm

AMERICAN TOAD
Anaxyrus americanus

Found in eastern North America, this toad is quite variable in color. Breeding occurs in ponds where males produce long trilling calls.

VARIABLE HARLEQUIN TOAD
Atelopus varius

This aggressive species from Panama and Costa Rica has vivid and variable coloration. It lives near streams and is active during the day.

1–2½ in
2.5–6 cm

1½–3½ in
4–8 cm

TRUANDO TOAD
Rhaebo haematiticus

Living among leaf litter in forests of Central and South America, this broad-headed toad lays its eggs in long strings in rocky pools.

1–1½ in
2.5–4 cm

GUYANAN STUBFOOT TOAD
Atelopus barbotini

This small toad from Guyana has a flattened body. It breeds throughout the year in forest streams.

2–4 in
5–10 cm

PANAMANIAN GOLDEN TOAD
Atelopus zeteki

This brightly colored frog from Panama breeds in pools after heavy rain. It may now be extinct in the wild.

3½–8 in
8–20 cm

EUROPEAN COMMON TOAD
Bufo bufo

Found throughout Europe and North Africa, this species breeds in spring, with males outnumbering the much larger females by about three to one.

2½–3¾ in
5.5–9.5 cm

GREEN CLIMBING FROG
Incilius coniferus

Native to Central and South America, this nocturnal toad is often found climbing among vegetation.

4–9½ in
10–24 cm

CANE TOAD
Rhinella marina

One of the world's largest toads, this American species was introduced in Australia, where it is now a serious threat to native wildlife.

CYCLORAMPHIDAE

This family, found in South America, includes Darwin's frog and a number of species that have coloration and hornlike projections that enable them to mimic the appearance of dead leaves.

1–1½ in
2–3 cm

DARWIN'S FROG
Rhinoderma darwinii

Found in Chile and Argentina, this frog has a unique form of parental care—the young develop from egg to froglet in their father's vocal sacs.

ELEUTHERODACTYLIDAE

This group of frogs, whose eggs develop directly into froglets, is found throughout the southern US, the Caribbean, and northern South America. Some species that are extremely small have reduced numbers of digits, and produce very small numbers of eggs—sometimes only one.

1–3¼ in
1.5–8 cm

PUERTO RICAN COQUI
Eleutherodactylus coqui

Native to Puerto Rico, this frog gets its name from its two-part call—the "co" is a warning to other males and the "qui" attracts females.

½–1 in
1.5–2.5 cm

CARETTA ROBBER FROG
Diasporus diastema

This small and very agile frog is arboreal and active at night. It lays its eggs in water-filled cavities in bromeliads growing epiphytically in trees.

CANE TOAD
Rhinella marina

One of the largest toads in the world, the cane toad is a hardy creature with a huge appetite. Also known as the marine toad, it is mainly a resident of dry environments, scrub, and savanna. It commonly lives around human settlements and is often seen under streetlights, waiting for insects to fall. The female is larger than the male, and the largest females can lay more than 20,000 eggs in a single clutch. Males attract females with a slow, low-pitched trill. They have few enemies because at all stages of their life cycle they are distasteful or toxic to potential predators. In Australia they have become a major pest—they are poisonous to native and domestic animals, injurious to humans, and breed so prolifically as to be out of control.

SIZE 4–9½ in (10–24 cm)
HABITAT Nonforested habitats
DISTRIBUTION Central and South America; introduced to Australia and elsewhere
DIET Terrestrial invertebrates

NIGHT HUNTER >
Protected by their poisonous skin and unafraid of predators, cane toads emerge at night from their daytime hiding places to hop about in search of prey.

^ PALE BELLY
The cane toad's belly and throat are relatively smooth, and mostly pale in color. Toads have permeable skin and must hide by day to conserve water.

DEBATE

PEST CONTROL

The cane toad gets its name from Australia, where it was introduced into Queensland in 1935 to control insect pests on sugar cane farms. The toads flourished in Australia, feasting on native fauna and building up much denser populations than in their native habitat. Still spreading at an alarming rate, they now occur throughout eastern and northern Australia, and are likely to migrate further. Scientists are working on methods to limit their numbers and contain their territorial expansion.

nostril

wide mouth used to take prey of any size that will fit inside it

male's throat is distended when he produces his loud, trill-like mating call

V IRIDESCENT IRIS
Like most toads, cane toads have large, protruding eyes. They have very good eyesight, enabling them to detect small, moving objects and to lunge accurately at their insect prey.

GLAND >
The enormous parotoid glands — located on each side of the head — secrete a powerful toxin that is distasteful to some predators and lethal to most.

^ NOSTRIL
The cane toad relies more on its sense of smell to find food than other toads — and breathes more with its lungs than with its skin.

EAR >
Toads rely on their hearing to identify potential enemies. At night, it is especially important for females, who also locate males by their calls.

FRONT FOOT ^
In the breeding season, males develop dark, horny nuptial pads on their first three fingers. These enable them to clasp females firmly during mating.

< HIND FOOT
The long toes on the hind foot, each with a horny tip, provide a firm grip on the ground when a toad pushes off to hop or jump.

prominent warts

WEBBING >
Compared with many other frogs and toads, cane toads have poorly developed webbing between their toes. This reflects the relatively small part of their lives spent in water.

web of skin

CRYPTIC FOREST FROGS

Found in South and Central America, this small family of frogs, the Aromobatidae, is closely related to poison-dart frogs, but does not produce toxic skin secretions. Most are cryptically colored.

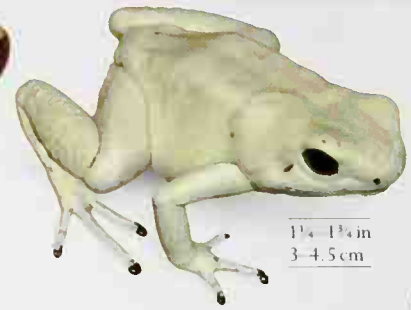
BRILLIANT-THIGHED POISON FROG
Allobates femoralis
The male of this South American species guards the eggs laid by the female in leaf nests. Later, he carries the tadpoles to water on his back.

POISON-DART FROGS

Called poison or poison-dart frogs, the Dendrobatidae are noted for their bright coloration. This warns predators that the skin of these frogs contains powerful toxins, which are derived from their insect food. These frogs are found in the forests of Central and South America. They are active by day.

MIMIC POISON FROG
Ranitomeya imitator
Found in Peru, this frog is variable in color and is similar in appearance to at least three other frog species.

LOVELY POISON-DART FROG
Phyllobates lugubris
This poisonous frog is found in leaf litter of lowland forests from Nicaragua to Panama. The male cares for the eggs and tadpoles.



GOLDEN POISON FROG
Phyllobates terribilis
Possibly the most toxic of all poison-dart frogs, this terrestrial species occurs in lowland forests of Colombia.

MARSUPIAL FROGS

Found in South and Central America, the Hemiphractidae carry their eggs on their back, where they hatch directly into froglets. Some also carry the eggs in a pouch, hence the name "marsupial frogs."

RAIN FORESTROCKET FROG
Silverstoneia flotator
This frog is found in Costa Rica and Panama. Its tadpoles have an upward-tilting mouth, which helps them feed from the water surface.

THREE-STRIPED POISON FROG
Ameerega trivittata
This South American frog calls by day, especially after rain. It lays its eggs in leaf litter and is common near human settlements.

HORNED MARSUPIAL FROG
Gastrotheca cornuta
The female of this canopy-dwelling Central and South American species lays large eggs that develop in a pouch on her back.

SUMACO HORNED TREEFROG
Hemiphractus proboscideus
This species is found in Colombia, Ecuador, and Peru. The female carries her eggs on her back, but does not have a pouch.

REED AND SEDGE FROGS

Also called African tree frogs, this large family, the Hyperoliidae, includes many agile climbers that gather in trees, bushes, or reeds near water to find mates and lay eggs. Some of the species are brightly colored, with marked differences between the sexes.

FOULASSI BANANA FROG
Afrixalus paradorsalis
Found in West Africa, this frog lays its eggs in a folded leaf above water. The male attracts females with a clicklike call.

RED-LEGGED KASSINA
Kassina maculata
This is an aquatic East African frog with adhesive discs on its toes. Its eggs, laid on submerged vegetation, hatch into large tadpoles.

GREEN AND BLACK POISON-DART FROG
Dendrobates auratus
The males of this species fight to secure a territory. The male defends the eggs and, when they hatch, carries tadpoles to small pools in tree holes.

1¼–2¼in
2.5–6cm

bright red body

rounded snout

toes with adhesive pads

STRAWBERRY POISON FROG
Oophaga pumilio
The female of this species cares for the young by carrying tadpoles to water-filled tree holes and feeding them with unfertilized eggs.

1¼–2in
3–5cm

1¼–1½in
3–4cm

YELLOW-HEADED POISON FROG
Dendrobates leucomelas
Found in wet forests of northern South America, this frog derives its skin toxin from the ants on which it feeds.

bright blue skin

long forelimbs

1¾–2in
4–5cm

DYEING POISON FROG
Dendrobates tinctorius
This South American species is quite variable in color. Both sexes protect the eggs and are very aggressive while defending their territory.

1¼–1½in
3–4cm

SPLASHBACK POISON FROG
Adelphobates galactonotus
Living in leaf litter in Brazilian forests, this frog lays eggs on the ground and carries the tadpoles to water.

1–1¼in
2.5–3cm

RIO MADEIRA POISON FROG
Adelphobates quinquevittatus
Found in Brazil and Peru, this tiny frog carries its tadpoles to water-filled holes, where the female feeds them with unfertilized eggs.

¾–1in
2cm

GRANULAR POISON FROG
Oophaga granulifera
This species is found in Costa Rica and Panama. Females care for the young by feeding them unfertilized eggs.

¾–1in
2–2.5cm

BRAZIL-NUT POISON FROG
Adelphobates castaneoticus
This species is found in Brazil. The males of this frog place tadpoles individually into small, water-filled tree holes. The tadpoles are voracious feeders.

1¼–1¾in
3–4.5cm

SMITH'S REED FROG
Hyperolius tuberilinguis
This agile frog is noted for its loud call. In the mating season, thousands of males may gather around a pond to produce a deafening chorus.

large adhesive disc on toe

1¾–2¼in
4.5–6cm

large eyes

BOLIHAMBA REED FROG
Hyperolius bolifambae
This small West African frog occurs in bushland, and breeds in pools. The male's call is a high-pitched buzz.

AUSTRALIAN GROUND FROGS

The Limnodynastidae, found in Australia and New Guinea, include many terrestrial and burrowing frog species. Two recently extinct species uniquely brooded their eggs in the stomach.

1¼–2¼in
3–6cm

BROWN-STRIPED MARSH FROG
Limnodynastes peronii
This Australian frog survives dry periods by burying itself in the ground. It emerges to breed after heavy rain, and deposits its eggs in floating foam nests.

TREE FROGS

The Hylidae are a large family widespread worldwide. They are especially well represented in the New World. These frogs have long, slender limbs and adhesive discs on their fingers and toes. Most are arboreal and nocturnal. Many gather to breed in noisy choruses.

2–3½ in
5–9 cm

SPLENDID LEAF FROG
Cruziohyla calcarifer

This frog occurs in Central and northern South America and lives high up in trees. It glides from one tree to another, using its extended webbed feet as parachutes.

1–1½ in
2.5–4 cm

RUFOUS-EYED STREAM FROG
Duellmanohyla rufioculis

Found in forests of Costa Rica, this frog breeds in fast-flowing streams. Its tadpoles have modified mouths with which they attach themselves to rocks.

¾–1¼ in
2–3 cm

SPRING PEEPER
Pseudacris crucifer

Found in moist woodland in the eastern US and Canada, the spring peeper's distinctive high-pitched call indicates that spring is underway.

2–2¾ in
5–7 cm

PARADOX FROG
Pseudis paradoxa

This aquatic frog is so named because its tadpoles are four times longer than the adult. It is found in South America and Trinidad.

2¾–3½ in
7–9 cm

MISSION GOLDEN-EYED TREEFROG
Trachycephalus resinifictrix

Found high in the canopy of South American forests, this frog lays its eggs in water-filled tree holes. The tadpoles develop into froglets.

2¼–3 in
5.5–7.5 cm

ROSENBERG'S TREEFROG
Hypsiboas rosenbergi

Males of this Central and South American frog dig pools in damp ground in which the eggs are laid. They defend them against rivals in fights that can be fatal.

1½–2 in
4–5 cm

ORANGE-LEGGED LEAF FROG
Phyllomedusa hypochondrialis

A native of dry habitats in northern South America, this climbing frog reduces water loss by rubbing a waxy secretion over its skin.

2¼–4¼ in
5.5–11 cm

COPE'S BROWN TREEFROG
Ecnomiohyla miliaria

This large Central American tree frog has fringes of skin on the limbs that may enable it to glide from one tree to another.

1½–2¼ in
3.5–5.5 cm

BOULENGER'S SNOUTED TREE FROG
Scinax boulengeri

Found in Central America and Colombia, this frog breeds in temporary pools created after rain. Males return night after night to the same calling perch to attract mates.

1–4 in
2.5–10 cm

CUBAN TREEFROG
Osteopilus septentrionalis

Native to Cuba, the Cayman Islands, and the Bahamas, this tree frog has been introduced to Florida, where it preys on native frogs, reducing their population.

1¼–2 in
3–5 cm

EUROPEAN TREEFROG
Hyla arborea

Males of this European tree frog gather in spring, calling in loud choruses to attract females. Mating pairs descend to lay eggs in nearby ponds.

1½–2¾ in
4–7 cm

RED-EYED TREE FROG
Agalychnis callidryas

An excellent climber, this tree frog mates in trees overhanging water. It lays its eggs on leaves and, upon hatching, the tadpoles fall into the water.

1¼–2 in
3–5 cm

LEMUR FROG
Agalychnis lemur

This Central American tree frog is nocturnal, sleeping on the underside of leaves during the day. It lays its eggs on leaves over water.

2¾–4 in
7–10 cm

MANAUS SLENDER-LEGGED TREEFROG
Osteocephalus taurinus

This arboreal frog lives in South American forests. It mates after rain, and lays its eggs on the surface of pools.

SMALL-HEADED TREE FROG
Dendropsophus microcephalus
Found in Central and South America and Trinidad, this frog breeds in pools. It is pale yellow by day, and red-brown by night.

¾–1¼ in
2–3 cm

NEW ZEALAND FROGS

This family, the Leiopelmatidae, is composed of four species of frogs that are all confined to New Zealand. They are characterized by extra vertebrae and, unlike most frogs, they kick their legs alternately when swimming. They live in humid forests and are nocturnal.

LEIUPERIDAE

This family is composed of a small group of South and Central American frogs. These frogs are active at night and mostly dwell on the ground. The best-known species of the family Leiuperidae is the Túngara frog.

horizontal pupils

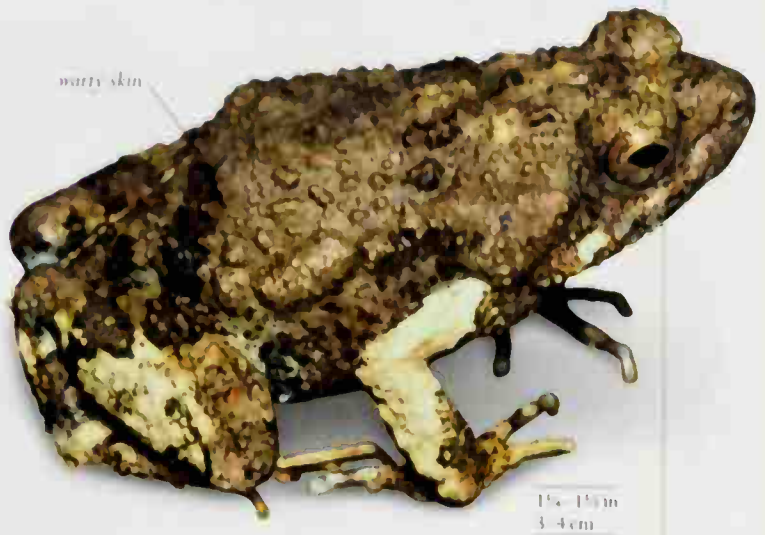
2–4 in
5–10 cm

AUSTRALIAN GREEN TREE FROG
Litoria caerulea
Found in northeast Australia and New Guinea, this agile climber is often found close to human habitations.

1–1½ in
2.5–4 cm

COROMANDEL NEW ZEALAND FROG
Leiopelma archeyi
Found only in New Zealand's North Island, this terrestrial frog lays its eggs under logs. It is critically endangered, as a result of habitat loss and disease.

warty skin



1¼–1½ in
3–4 cm

TÚNGARA FROG
Engystomops pustulosus
During mating, the female of this Central American species produces a secretion that the male whips into a floating foam nest in which the eggs are laid.

MANTELLAS

Found only on the islands of Madagascar and Mayotte, the Mantellidae are active by day. Many are brightly colored, warning predators of powerful toxins in their skin. Most species are threatened by the loss of habitat and by the international pet trade.

2–2¼ in
5–6 cm

2¼–3¼ in
6–8 cm

SPINY-HEADED TREEFROG
Anotheca spinosa
Native to Mexico and Central America, this frog lives in bromeliads and banana plants, laying its eggs in water-filled cavities.

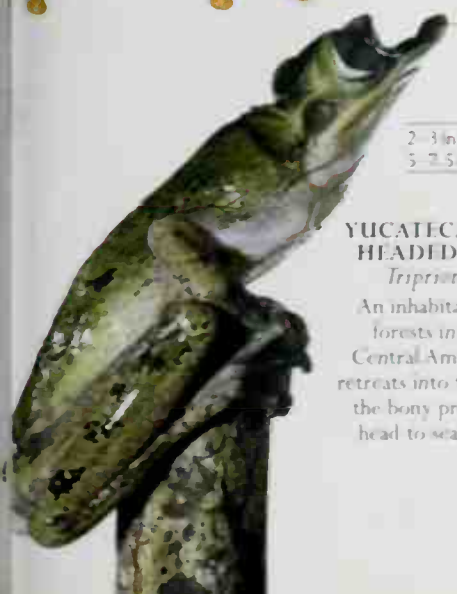
1¾–3¼ in
4.5–8 cm

WHITE-LIPPED BRIGHT-EYED FROG
Boophis albilabris
This large arboreal frog, found only in Madagascar, lives near the streams in which it breeds. It has fully webbed hind feet.

1½–3¼ in
4–8 cm

MASKED TREEFROG
Smilisca phaeota
Active at night in humid forests in Central and South America it lays its eggs in small pools.

bony projection



2–3 in
5–7.5 cm

YUCATECAN SHOVEL-HEADED TREEFROG
Triprion petasatus
An inhabitant of lowland forests in Mexico and Central America, this frog retreats into tree holes, using the bony projection on its head to seal the opening.

rough, moss skin

¾–1¼ in
2–3 cm

MADAGASCAN GOLDEN MANTELLA
Mantella aurantiaca
The bright color of this tiny frog from Madagascan rain forests warns potential predators that its skin secretes a powerful toxin.

¾–1 in
2–2.5 cm

PAINTED MANTELLA
Mantella madagascariensis
This Madagascan frog breeds in forest streams. It is under threat due to loss of habitat. The male's call consists of short chirps.

NARROW-MOUTHED FROGS

Frogs of the large and diverse family Microhylidae are found in the Americas, Asia, Australia, and Africa. Most are ground dwelling and some live in burrows. Most have stout hind legs, short snouts, and plump, often teardrop-shaped, bodies.

2–3 in
5–7.5 cm

PAINTED TOAD
Kaloula pulchra
Widespread in Asia, this species has adapted well to human settlements. It protects itself with a noxious, sticky skin secretion.

3¼–4¾ in
8–12 cm

TOMATO FROG
Dyscophus antongilii
Native to Madagascar, this frog stays buried in soil by day, emerging to feed at night. A sticky skin secretion protects it against predators.

1¼–2¼ in
3–6 cm

BLACK-SPOTTED NARROW-MOUTHED FROG
Kalophrynus pleurostigma
This frog from the Philippines protects itself by producing a sticky secretion. It breeds in small pools after rain.

¾–1½ in
2–3.5 cm

EASTERN NARROW-MOUTHED TOAD
Gastrophryne carolinensis
Found in the southeastern US, this burrowing toad breeds in water bodies of all sizes. The male's call sounds like a bleating lamb.

¾–1 in
2–2.5 cm

GIANT STUMP-TOED FROG
Stumpffia grandis
This small terrestrial frog is found in leaf litter in high-altitude forests in Madagascar.

MEGOPHRYIDAE

Found across Asia, this is a small family of frogs whose body shape and color patterns enable them to be camouflaged among leaves. They walk rather than jump, and most are ground living.

2¾–5½ in
7–14 cm

ASIAN HORNED FROG
Megophrys nasuta
The "horns" and coloration of this frog enable it to conceal itself among dead leaves, while it waits for prey.

PARSLEY FROGS

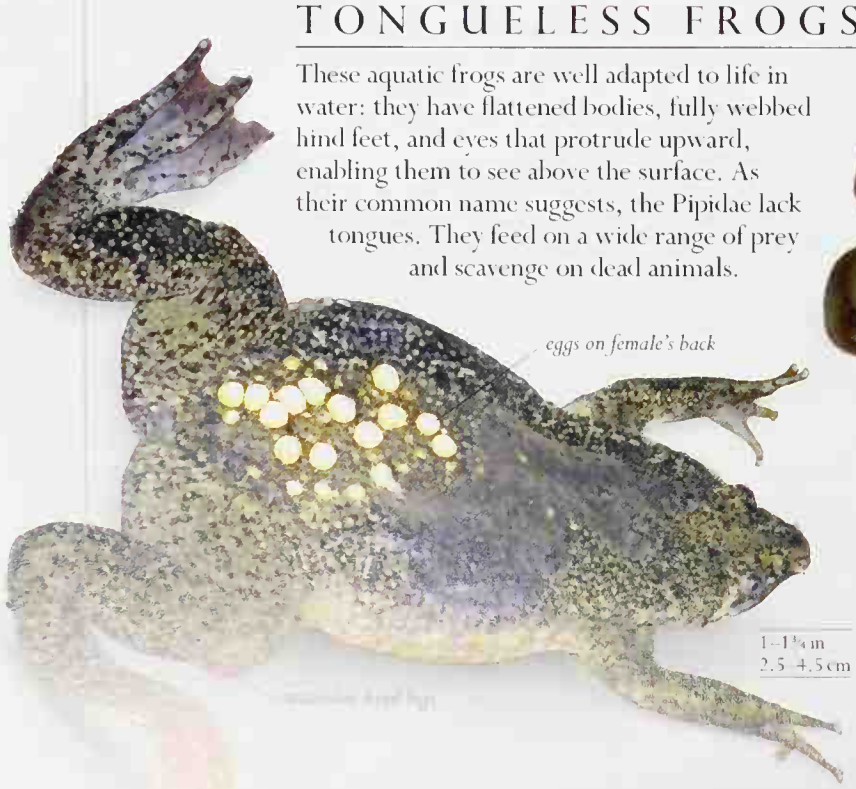
Made up of only three species, the family Pelodytidae is confined to Europe and the Caucasus. Named for the green markings on their skin, parsley frogs breed after rain, laying their eggs in broad strips.

1¼–2 in
3–5 cm

COMMON PARSLEY FROG
Pelodytes punctatus
When climbing smooth, vertical surfaces, this European frog uses its underside as a sucker. Both sexes call during breeding.

TONGUELESS FROGS

These aquatic frogs are well adapted to life in water: they have flattened bodies, fully webbed hind feet, and eyes that protrude upward, enabling them to see above the surface. As their common name suggests, the Pipidae lack tongues. They feed on a wide range of prey and scavenge on dead animals.



1–1¾ in
2.5–4.5 cm

1¼–2 in
3–5 cm

FRASER'S CLAWED FROG
Xenopus fraseri
Found in West and central Africa, this wholly aquatic frog thrives in human-altered habitats and is harvested by people for food.

DWARF SURINAM TOAD
Pipa parva
In this wholly aquatic species found in Venezuela and Colombia, the eggs develop on the female's back.

SPADEFOOT TOADS

A small family found in Eurasia and North Africa, the Pelobatidae are characterized by horny projections on their hind feet. They use them to burrow into the ground, where they wait for rain.

1½–3¼ in
4–8 cm

COMMON SPADEFOOT TOAD
Pelobates fuscus
Found in Europe and Asia, this species is variable in color. It has a plump body, which it inflates when attacked.

DICROGLOSSIDAE

This diverse family of frogs is found across Africa, Asia, and several Pacific islands. Most are ground living, but are found close to water. Many lay their eggs in water and have free-living tadpoles.

1¼–2¼in
3–6cm

MARTIN'S PUDDLE FROG
Occidozyga martensii
Found in China and Southeast Asia, this small frog occurs in pools near forest streams and rivers.

1½–2½in
4–6.5cm

2½–6¾in
6.5–17cm

INDIAN BULLFROG
Hoplobatrachus tigerinus
This large, voracious feeder from southern Asia breeds during the monsoon. The male has a particularly loud call.

RAJAMALLY WART FROG
Fejervarya kirtisinghei
Found only in Sri Lanka, this frog lives in leaf litter near streams and thrives in plantations and gardens.

1–1½in
2.5–4.5cm

COMMON SKITTERING FROG
Euphlyctis cyanophlyctis
Widespread in southern Asia, this aquatic frog is noted for its ability to skitter over the surface of water.

TRUE FROGS

Known as true frogs, this large family is found in most parts of the world. Most of the Ranidae have powerful hind limbs that enable them to jump athletically on land and to swim powerfully in water. They typically breed in early spring, with many laying their eggs communally.

powerful hind legs for swimming

4–16in
10–40cm

GOLIATH FROG
Conraua goliath
The world's largest frog, this West African species has an aquatic lifestyle, its powerful legs and webbed feet make it a strong swimmer.

long, webbed toes

3½–4¾in
8–12cm

EDIBLE FROG
Pelophylax esculenta
This frog is a hybrid between the widespread European *Pelophylax kl. esculentus* and other more local species. It lives in and close to water.

1½–3½in
3.5–8cm

WOOD FROG
Lithobates sylvaticus
The only American frog found north of the Arctic Circle, it breeds in early spring in temporary pools free of fish.

black spots on green to brown body

white vocal sac

2–4in
5–10cm

male has black forelimbs

EUROPEAN COMMON FROG
Rana temporaria
Also known as the grass frog, this species lives mostly on land, migrating to ponds in spring to breed. It lays eggs in clumps.

2¼–2¾in
6–7cm

PICKEREL FROG
Lithobates palustris
Found over much of North America, this frog breeds in spring, with females laying their eggs in clumps containing two to three thousand eggs.

3½–8in
9–20cm

AMERICAN BULLFROG
Lithobates catesbeianus
This voracious predator has tadpoles that may take four years to develop, reaching a large size. It is the largest North American frog.

PHRYNOBATRACHIDAE

This family of small, terrestrial or semiaquatic frogs is confined to sub-Saharan Africa. Most breed throughout the year, laying their eggs in water. They reach maturity in five months.

GOLDEN PUDDLE FROG
Phrynobatrachus auritus
This frog is so named because it breeds in very small pools. A ground-dwelling species, it is found in central African rain forests.

ORNATE FROGS AND GRASS FROGS

Found in open country in Africa, Madagascar, and the Seychelles, the Ptychadenidae include many brightly colored frogs. Streamlined bodies and strong hind legs make them prodigious jumpers.

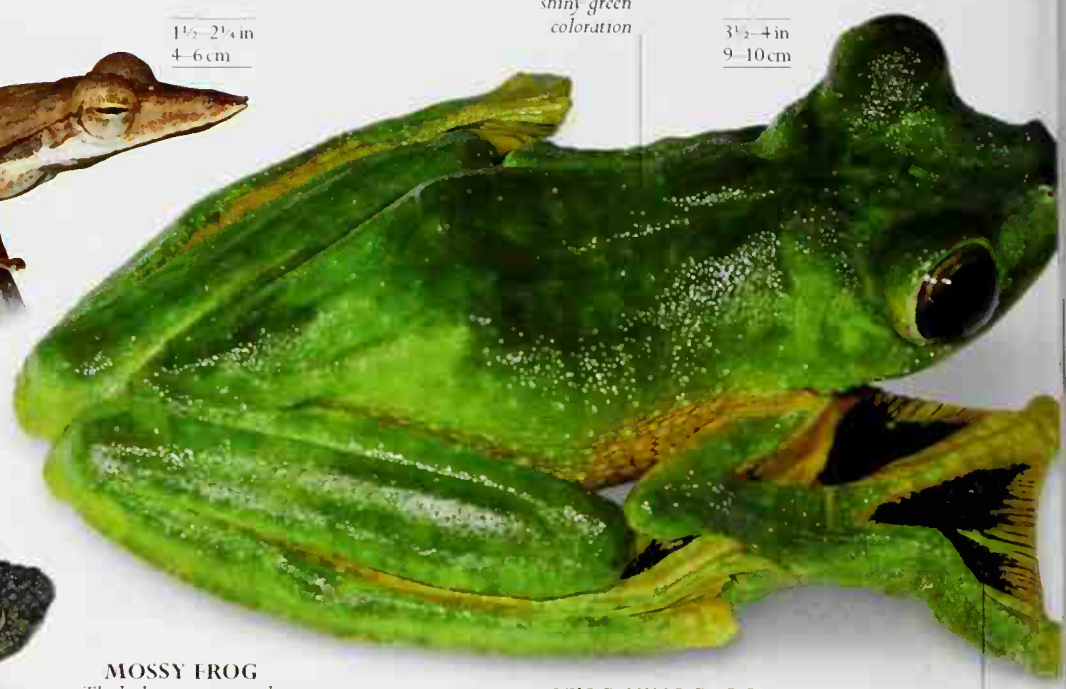
MASCARENE RIDGED FROG
Ptychadena mascareniensis
Common on agricultural land, this frog has long legs and a pointed snout. It breeds in puddles, wheel ruts, and ditches.

AFRO-ASIAN TREE FROGS

The Rhacophoridae range across Africa and much of Asia, and are mostly arboreal frogs. The family includes flying frogs that glide from tree to tree. Many lay their eggs in foam nests, where the eggs and tadpoles stay protected against predators.

SOUTHERN WHIPPING FROG
Polypedates longinasus
Endangered by the loss of much of its habitat, this arboreal frog occurs in Sri Lanka's remaining patches of rain forest.

AFRICAN FOAM-NEST TREE FROG
Chiromantis rufescens
Found in the forests of West and Central Africa, this frog lays its eggs in a foam nest attached to a branch overhanging water.



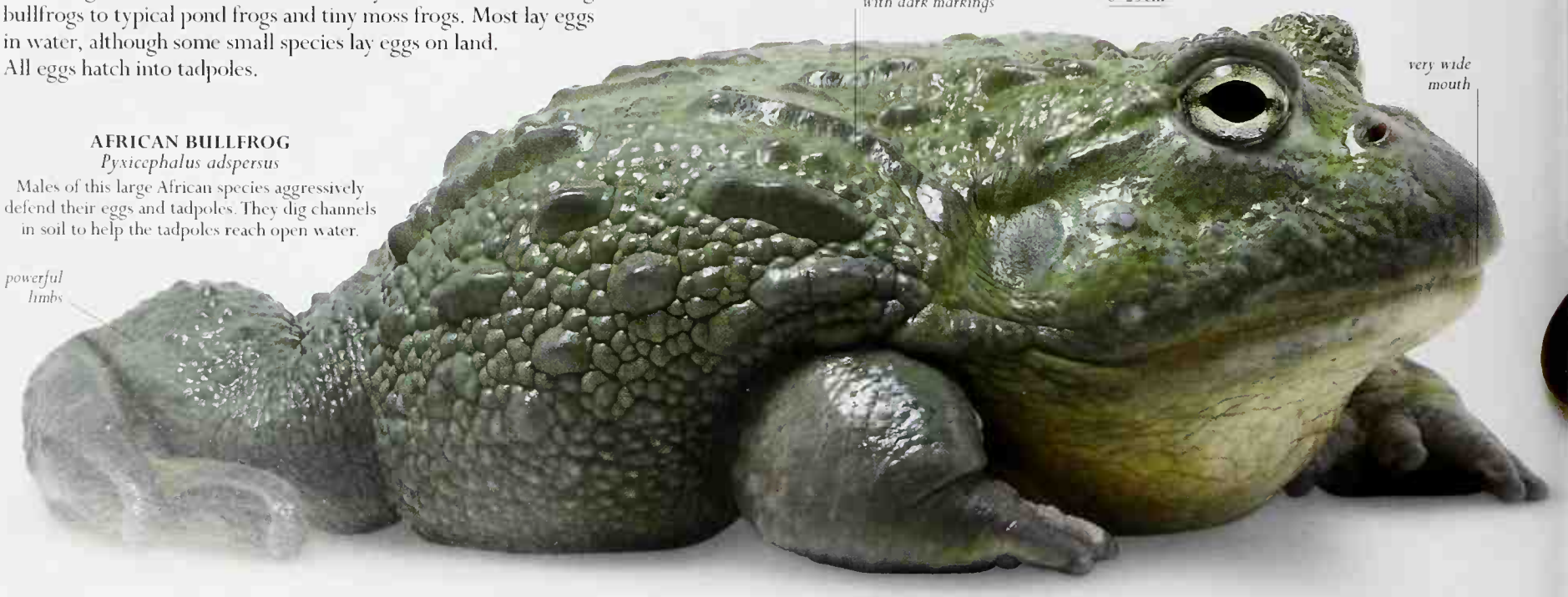
MOSSY FROG
Theloderma corticale
The warty skin and green color of this Vietnamese frog camouflages it against moss. It curls into a ball when threatened.

WALLACE'S FLYING FROG
Rhacophorus nigropalmatus
This arboreal species from the rain forests of Southeast Asia has webbed feet that enable it to glide between trees.

long, fully webbed fore- and hind feet

PYXICEPHALIDAE

Inhabiting sub-Saharan Africa, this family varies in size from huge bullfrogs to typical pond frogs and tiny moss frogs. Most lay eggs in water, although some small species lay eggs on land. All eggs hatch into tadpoles.



AFRICAN BULLFROG
Pyxicephalus adspersus
Males of this large African species aggressively defend their eggs and tadpoles. They dig channels in soil to help the tadpoles reach open water.

MEXICAN BURROWING TOAD

The only member of the family Rhinophrynidae, the burrowing toad specializes in digging in soil and eating ants. It has a long, thin tongue that it sticks out of its narrow mouth.

2¼–3¼ in
6–8 cm

MEXICAN BURROWING TOAD
Rhinophrynus dorsalis
This unusually shaped toad spends most of its life burrowing underground, emerging only after rain to breed in temporary pools.

AMERICAN SPADEFOOT TOADS

This family consists of toads that live on dry land and stay inactive underground for long periods. The Scaphiopodidae emerge after rain to breed in temporary pools. These may evaporate quickly, so the tadpoles develop very rapidly.

2¼–3½ in
5.5–9 cm

mottled greenish brown skin

1¼–2¼ in
4–6 cm

PLAINS SPADEFOOT
Spea bombifrons
Found in arid plains of North America, this frog burrows by day. It gathers to breed in large numbers after heavy rain.

COUCH'S SPADEFOOT
Scaphiopus couchii
This North American frog lives in arid areas, spending much of its time underground. It emerges at night to feed and, after heavy rain, to breed.

STRABOMANTIDAE

Many small frogs native to South America and the Caribbean make up this family. They are all direct developers: there is no tadpole stage and the egg hatches straight into a miniature adult.

LIMON ROBBER FROG
Pristimantis cerasinus
Hiding in leaf litter by day, but arboreal by night, this small frog is found in humid lowland forests of Central America.

¾–1¼ in
1.5–3.5 cm

¾–1½ in
2–4 cm

CHIRIQUI ROBBER FROG
Pristimantis cruentus
This small, terrestrial frog, found in Central and South America, lays its eggs in crevices on tree trunks.

½–1 in
1.5–2.5 cm

PYGMY RAINFROG
Pristimantis ridens
Found in the forests of Central and South America, this tiny nocturnal frog thrives in gardens and lays its eggs in leaf litter.

CAECILIANS

Caecilians are long-bodied, limbless amphibians with little or no tail. Ring-shaped folds (annuli) in the skin give them a segmented appearance.

All caecilians live in the tropics. They vary in length from 4¾ in (12 cm) to 5¼ ft (1.6 m). Most live underground, burrowing in soft soil, using their pointed, bony head as a shovel. They emerge at night, especially after rain, to feed on earthworms, termites, and other insects. Others live in water and resemble eels, rarely moving onto the land. These have a fin on the tail. With only rudimentary eyes, all rely on smell to find food and mates. A pair of retractable tentacles between the eyes and the nostrils transmit chemical signals to the nose.

In all caecilians, the eggs are fertilized internally. Some species lay eggs, but in others the eggs are retained inside the female's body. The young emerge either as gilled larvae or as small adults.

PHYLUM	CHORDATA
CLASS	AMPHIBIA
ORDER	GYMNOPHIONA
FAMILIES	6
SPECIES	186

20 in
50 cm

PURPLE CAECILIAN
Gymnopis multiplicata
This terrestrial caecilian from Central America lives in a wide range of habitats. The eggs hatch inside the female.

ICHTHYOPHIIDAE

Found in Asia, these caecilians lay eggs in soil near water. Females remain with their clutches, defending them until the larvae have made their way to open water.

15in
11cm

yellow stripe along body

KOH TAO CAECILIAN
Ichthyophis kohtaoensis
Found in a variety of habitats in Southeast Asia, this caecilian lays its eggs on land, but its larvae live in water.

CAECILIIDAE

Most species in this family are burrowers. Found in most tropical regions of the world, they vary greatly in length, some growing to over 5 ft (1.5 m). In some the eggs hatch into larvae; in others the larvae develop inside the female.

2in
63cm

CONGO CAECILIAN
Herpele squalostoma
From West and Central Africa, this caecilian lives underground and is found near streams and rivers in lowland forests.

9in
22cm

SLENDER CAECILIAN
Dermophis parviceps
Living underground in the wet forests of Central and South America, this slender caecilian emerges to forage at night.

SALAMANDERS AND NEWTS

Unlike their fellow amphibians, the frogs, salamanders and newts normally have slender, lizardlike bodies, long tails, and four legs similar in size.

Newts and salamanders, also known as urodeles, are generally found in damp habitats and are largely confined to the northern hemisphere. They are numerous in the Americas, ranging from Canada to northern South America. They vary considerably in size, from species over 3¼ ft (1 m) in length, to tiny creatures about ¾ in (2 cm) long.

AMPHIBIOUS LIFESTYLES

Some species, notably the newts, spend part of their life in water, part on land. Some salamander species live their entire lives in water, while others are wholly terrestrial. Most have smooth, moist skin through which they breathe to a greater or lesser extent.

The salamanders of one family, the plethodontids, have no lungs and breathe entirely through their skin and the roof of their mouths. Urodeles have relatively small heads, compared with frogs and toads; they also have smaller eyes, smell being the most important sense used in finding food and in social interactions. Most species, especially the terrestrial ones, are nocturnal, hiding under a log or rock during the day.

REPRODUCTION

In the majority of species, the eggs are fertilized inside the female. Males, however, do not have a penis but package sperm in capsules called spermatophores which are passed to the female during mating. In many species sperm transfer is preceded by elaborate courtship in which the male induces the female to cooperate with him. She may, of course, reject his advances. In many newts, males develop dorsal crests and bright colors in the breeding season.

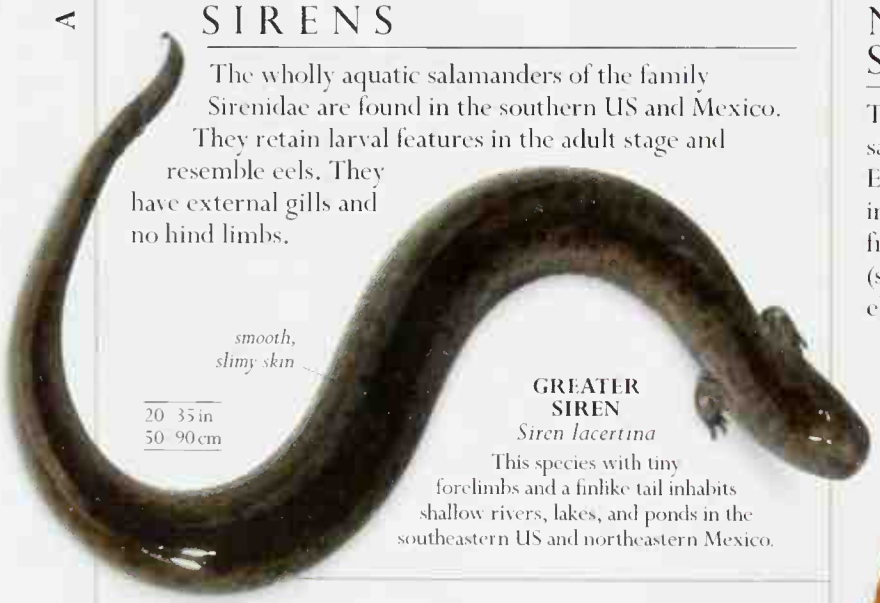
Many species lay their eggs in water. When the larvae hatch, they have long, slender bodies, deep, finlike tails, and large, feathery external gills. The larvae are carnivorous, feeding on tiny water creatures. The exceptions to this rule are the wholly terrestrial species of salamander. These lay their eggs on land and the larval stage is completed within the egg, which hatches to produce a miniature adult.

PHYLUM	CHORDATA
CLASS	AMPHIBIA
ORDER	CAUDATA
FAMILIES	10
SPECIES	585

A male alpine newt sniffs a female before courting her. Odor helps to identify the gender and species of potential partners.

SIRENS

The wholly aquatic salamanders of the family Sirenidae are found in the southern US and Mexico. They retain larval features in the adult stage and resemble eels. They have external gills and no hind limbs.



GREATER SIREN
Siren lacertina
This species with tiny forelimbs and a finlike tail inhabits shallow rivers, lakes, and ponds in the southeastern US and northeastern Mexico.

TORRENT SALAMANDERS

Confined to the extreme northwestern US, the Rhyacotritonidae are a small family of four species. These stocky, semiaquatic salamanders lay their eggs on rocks under water and have aquatic larvae.

COLUMBIA TORRENT SALAMANDER
Rhyacotriton kezeri
Confined to the forests of Oregon and Washington, this salamander lays its eggs in springs. Intensive logging has caused its numbers to decline considerably.

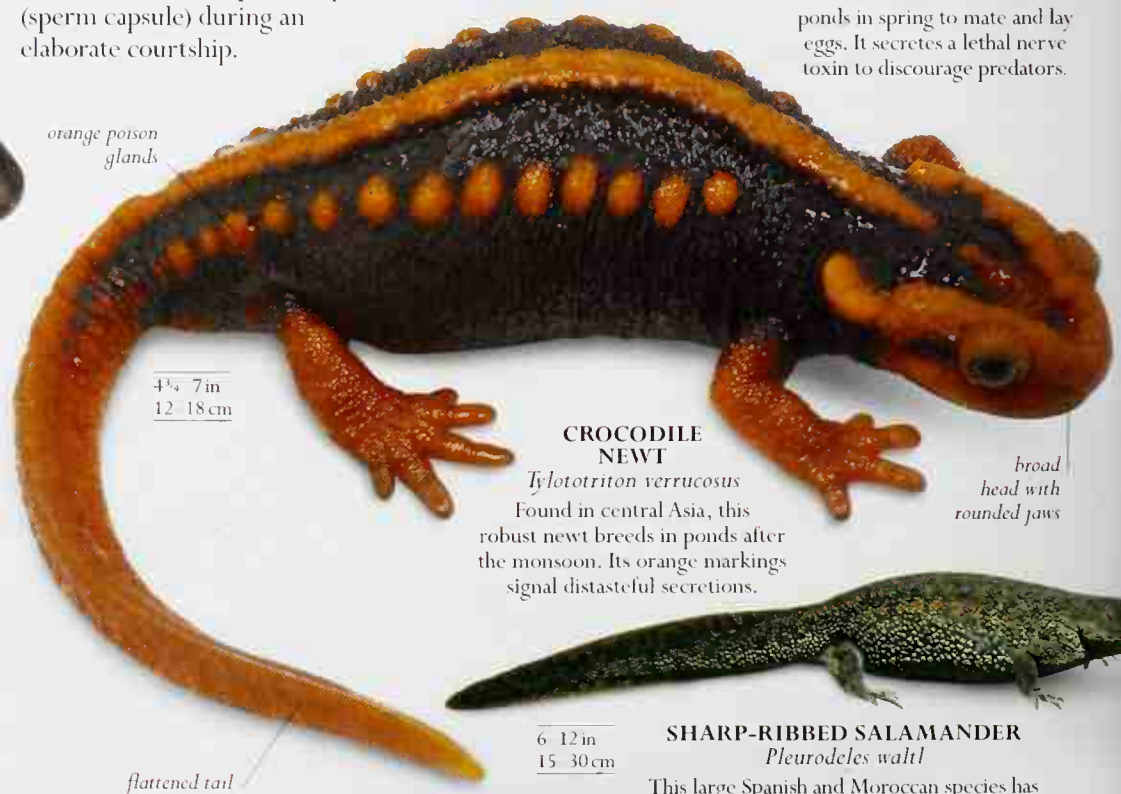
3–4½ in
7.5–11.5 cm

NEWTS AND EUROPEAN SALAMANDERS

The Salamandridae are small- and medium-sized salamanders and newts found in North America, Europe, North Africa, and Asia. Eggs are fertilized inside the female, with sperm being transferred from the male in a spermatophore (sperm capsule) during an elaborate courtship.

4¾–8 in
12–20 cm

CALIFORNIA NEWT
Taricha torosa
This nocturnal newt enters ponds in spring to mate and lay eggs. It secretes a lethal nerve toxin to discourage predators.



CROCODILE NEWT
Tylototriton verrucosus
Found in central Asia, this robust newt breeds in ponds after the monsoon. Its orange markings signal distasteful secretions.

6–12 in
15–30 cm

SHARP-RIBBED SALAMANDER
Pleurodeles waltl
This large Spanish and Moroccan species has a unique mode of defense. When grasped, it pushes out the sharp tips of its ribs through its skin.

cylindrical tail

blue markings on tail

orange underside

ALPINE NEWT
Ichthyosaura alpestris
Found across much of northern Europe, this newt breeds in early spring. The female wraps eggs individually in the leaves of water plants.

3½–4½ in
9–12 cm

3½–4 in
9–10 cm

SPECTACLED SALAMANDER
Salamandrina terdigitata
This secretive salamander is found only in Italy and lives in streams in hilly areas. It has a long, slender, and flattened body.

5–6½ in
13–17 cm

SPOTLESS STOUT NEWT
Pachytriton labiatus
Found in mountain streams in China, this newt is equipped with a large tail for swimming. It attaches its eggs to rocks.

7–11 in
18–28 cm

large, prominent eyes

4–5½ in
10–14 cm

SARDINIAN BROOK SALAMANDER
Euproctus platycephalus
Found only in Sardinia, this slender salamander lives in streams, laying its eggs under rocks. It is endangered due to degradation of its habitat.

FIRE SALAMANDER
Salamandra salamandra
This European salamander spends most of its time on land, entering water only to lay eggs. The glands on its head can spray a toxic secretion at enemies.

large glands secrete toxin

3½–5 in
9–13 cm

EASTERN NEWT
Notophthalmus viridescens
This pond-breeding newt is from eastern North America. Juveniles or "efts" are terrestrial, bright red in color, and very toxic.

2½–5½ in
6.5–14 cm

LORESTAN NEWT
Neurergus kaiseri
Found only in Iran, this species lives in streams. It is critically endangered due to loss of its habitat and its popularity as a pet.

orange and black limbs

3½–4½ in
9–12 cm

JAPANESE NEWT
Cynops pyrrhogaster
This newt spends much of its life in water. Its brightly colored belly warns potential predators that the glands in its skin secrete a toxin.

2¾–4 in
7–10 cm

SMOOTH NEWT
Lissotriton vulgaris
Common across Europe and western Asia, this small amphibian breeds in ponds. The male mates with the female after elaborate courtship.

GREAT CRESTED NEWT
Triturus cristatus
Found across Europe and central Asia, males of this large, pond-breeding species develop a spectacular dorsal crest in spring, and display it vigorously to potential mates.

4–7in
10–18 cm

MARBLED NEWT
Triturus marmoratus
Found in France and Spain, this newt lives in woodland, meadows, and hedgerows. It enters ponds to breed in spring.

4–5½ in
10–14 cm

LUNGLESS SALAMANDERS

Containing over 390 species, the Plethodontidae are the largest salamander family. Members of this family have no lungs, but breathe through their mouth and skin. Except for six European species, all live in North, Central, and South America, inhabiting a wide variety of habitats and feeding mainly on small invertebrates.

3¼–5 in
8–13 cm

CUKRA CLIMBING SALAMANDER
Bolitoglossa striatula
A small salamander with webbed digits, this species is nocturnal, hiding by day among banana leaves. It is found in Costa Rica, Honduras, and Nicaragua.

2¾–4¼ in
7–11 cm

ALLEGHANY MOUNTIAN DUSKY SALAMANDER
Desmognathus ochrophaeus
Mostly terrestrial, this salamander is often found foraging in forests in large numbers after heavy rain, and sometimes climbing trees and shrubs.

SEAL SALAMANDER
Desmognathus monticola
This stout-bodied species lives in a burrow by day and is active at night. It often perches on a rock.

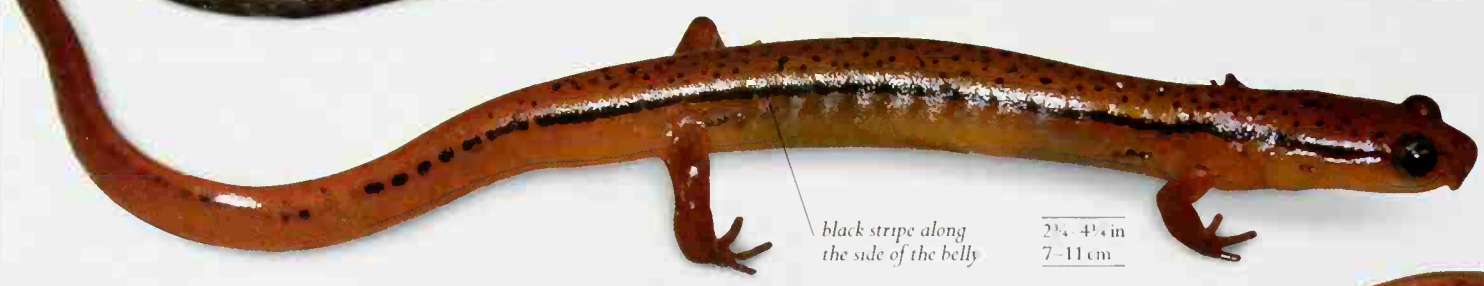
3¼–5 in
8–13 cm

4¼–6 in
11–15 cm

ALLEN'S WORM SALAMANDER
Oedipina alleni
Found in leaf litter in lowland forests of Costa Rica, this salamander coils up its elongated body and tail when attacked.

4–6½ in
10–16 cm

THREE-LINED SALAMANDER
Eurycea guttolineata
Found in and around water, the slender three-lined salamander is a very good swimmer, but spends much of its time in a burrow.



2¾–4¼ in
7–11 cm

BLUE RIDGE TWO-LINED SALAMANDER
Eurycea wilderae
Found around springs and streams, this small species is common in the wooded mountains of the southern Appalachians. It mates in fall and lays its eggs in winter.

4½–8½ in
11.5–21 cm

MISSISSIPPI SLIMY SALAMANDER
Plethodon mississippi
Found in hardwood forests, this terrestrial salamander protects itself from predators by producing a sticky skin secretion. It lays its eggs on land.

2¾–4¾ in
7–12 cm

REDBACK SALAMANDER
Plethodon cinereus
A terrestrial species, this salamander hides under bark by day and hunts for insects and other prey in foliage after dark.

GIANT SALAMANDERS

The Cryptobranchidae are three large, wholly aquatic species—one each from North America, Japan, and China. They feed on a wide variety of prey, from worms to small mammals. The family includes the world's largest salamander—the Chinese giant salamander, which is about 6 ft (1.8 m) long.

HELLBENDER
Cryptobranchus alleganiensis
This North American species has a flattened head that helps it dig a burrow under rocks, where the males guard the eggs. It has very wrinkled skin.

12–30 in
30–75 cm

3¾–4½ ft
1–1.4 m

JAPANESE GIANT SALAMANDER
Andrias japonicus
This aquatic species is threatened by degradation of its habitat. Some males, called "den masters," defend burrows in which females lay eggs.

4¼–7½ in
12–19 cm

SPRING SALAMANDER
Gyrinophilus porphyriticus
An agile inhabitant of mountain streams and springs, this colorful salamander is most commonly found hiding under a log or rock.

3½–4½ in
9–12 cm

ITALIAN CAVE SALAMANDER
Speleomantes italicus
Found near streams and springs in the mountains of northern Italy, this salamander lives in caves and rock crevices.

5–6 in
12.5–15.5 cm

ENSATINA SALAMANDER
Ensatina eschscholtzii
This smooth-skinned, North American salamander has a plump tail, which is narrow at the base. It waves its tail at enemies in a defensive posture.

2–3½ in
5–9 cm

FOUR-TOED SALAMANDER
Hemidactylium scutatum
A terrestrial salamander, the adults of this species live in mosses, but the larvae grow in water. There is a marked narrowing at the base of its tail.

ASIATIC SALAMANDERS

Around 50 small- to medium-sized species form the Hynobiidae. They are confined to Asia, with some found in mountain streams. They lay their eggs in ponds or streams, and their larvae have external gills. Some species have claws to grasp rocks.

4–6½ in
10–16 cm

OITA SALAMANDER
Hynobius dunni
Females of this endangered Japanese species produce eggs in sacs, and males then compete to fertilize them externally.

MOLE SALAMANDERS

These large creatures mostly live in burrows and emerge to forage by night. The Ambystomatidae contain 37 species, all found in North America. Some species, notably the Mexican axolotl, are aquatic as adults and retain larval features, such as external gills. The four large and aggressive species of the genus *Dicamptodon*, found in western North America, were formerly classified as a separate family.

4–12 in
10–30 cm

AXOLOTL
Ambystoma mexicanum
Adult axolotls never leave the water and resemble very large salamander larvae, with their deep tails and feathery external gills.

7–10 in
18–25 cm

TIGER SALAMANDER
Ambystoma tigrinum
A thick-set salamander found throughout much of North America, this species migrates in spring to ponds to mate and lay eggs.

3½–4½ in
9–11 cm

MARBLED SALAMANDER
Ambystoma opacum
This short-tailed, stocky salamander breeds in fall and lays its eggs in dried-up ponds that fill with rain in winter.

6½–12 in
17–30 cm

CALIFORNIA GIANT SALAMANDER
Dicamptodon ensatus
This large, nocturnal salamander is threatened by loss and degradation of its forest habitat. This species has an aquatic larval stage.

MUDPUPPIES AND RELATIVE

Five of the six species in the Proteidae are found in North America; the sixth one—the cave-living olm—lives in Europe. Members of this family retain the larval form into their adult life, with long, slender bodies, external gills, and small eyes.

8–20 in
20–50 cm

MUDPUPPY
Necturus maculosus
A voracious predator, the mudpuppy, or waterdog, feeds on a variety of invertebrates, fishes, and amphibians. The female aggressively defends her developing eggs.

8–12 in
20–30 cm

EUROPEAN OLM
Proteus anguinus
The wholly aquatic olm lives in dark, flooded caves in Slovenia and Montenegro. It is blind and has white, pink, or gray skin.

AMPHIUMAS

Occurring in eastern North America, the Amphiumidae are a family of three large, wholly aquatic salamanders with eel-like bodies and tiny limbs. Females guard the eggs in a nest on land. Amphiumas can survive drought by burrowing into mud and forming a cocoon. They feed on worms, mollusks, fish, snakes, and small amphibians.

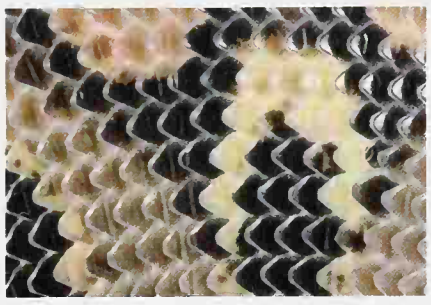
16–43 in
40–110 cm

THREE-TOED AMPHIUMA
Amphiuma tridactylum
This large salamander, with slimy skin and a long tail, can give a painful bite. Males breed every year, while females breed in alternate years.

REPTILES

Reptiles are a sophisticated, diverse, and successful group of ectothermic (cold-blooded) vertebrates. Although commonly associated with hot, dry environments, they are found in a wide range of habitats and climates around the world.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDERS	4
FAMILIES	60
SPECIES	About 7,700



Reptile scales are a protective layer of skin with overlapping patches thickened with keratin and sometimes bone.

The shelled egg allows reptiles to reproduce out of water. The outer layer protects the embryo from dehydration.

Crocodiles can walk with their body raised well off the ground, whereas turtles manage only a sprawling gait.

Reptiles modify their behavior to regulate body temperature. They bask in the morning sun to absorb heat energy.

The first reptiles evolved from amphibians more than 295 million years ago. They are the ancestors not only of modern-day reptiles but also of mammals and birds. During the Mesozoic Era, reptiles such as dinosaurs, aquatic ichthyosaurs and plesiosaurs, and aerial pterosaurs dominated Earth. Reptile groups that still exist today evolved in this period and survived the mass extinction event that killed off the dinosaurs 65 million years ago.

All reptiles share certain characteristics, such as scaly skin and behavioral thermoregulation—using outside sources to maintain a constant body temperature, by basking in the sun, for example. But the various groups exhibit obvious differences. Turtles and tortoises are protected by a unique, heavily armored shell. Lizards, crocodilians, and tuataras have four limbs and long tails. Many squamates, or scaled reptiles—lizards, snakes, and amphisbaenians—have evolved limbless forms.

Hot desert ecosystems are typically dominated by lizards and snakes, but reptiles of all types are found in all habitats in the tropics and subtropics. Fewer species are found in cooler temperate climates. Within each ecosystem reptiles are important both as predators and as prey. Most are carnivores, feeding on a wide range of other animals. A few large lizards and tortoises are exclusively herbivores, but many species are opportunistic omnivores.

BEHAVIOR AND SURVIVAL

Some species are solitary whereas others are highly social. Although sluggish and inactive when cool, once their preferred body temperature is reached by basking or pressing against a warm rock, they can be very active.

Reproductive behavior can be complex, with males actively defending territories and courting females. Although some squamates give birth to live young, in most cases the male reptile fertilizes the female, who then lays eggs in an underground nest. All reptiles are independent and self-feeding from birth, although some crocodilians give parental care for two or more years.

Reptiles are exploited by humans for their skin or as food. This, along with habitat loss, pollution, and climate change, threatens the survival of many species.

SEA TURTLE IN ITS ELEMENT >
The green turtle may appear primitive but, with efficient flippers and a flattened shell, is well adapted to its aquatic life.

REPTILE GROUPS

By the Mesozoic Era, reptiles had diversified. Turtles and crocodilians had diverged early on, and later the squamates—lizards, snakes, and amphisbaenians—appeared.

TURTLES AND TORTOISES
» 372

TUATARAS
» 379

LIZARDS
» 380

AMPHISBAENIANS
» 387

SNAKES
» 390

CROCODILES AND ALLIGATORS
» 400

TURTLES AND TORTOISES

With their bony shell, stout limbs, and toothless, beaklike mouth, turtles and tortoises have changed little from species that lived 200 million years ago.

The order includes sea turtles, freshwater turtles, and terrestrial tortoises. Some extinct turtles were gigantic, but most modern ones are more modestly sized. The exceptions are the large sea turtles and a few terrestrial tortoises inhabiting isolated islands.

PROTECTION AND LOCOMOTION

A turtle's shell is formed of numerous fused bones, overlaid by scutes. The domed upperpart is known as the carapace and the lower part, the plastron. Scutes are horny plates and new ones form beneath the old ones each year. The degree of protection provided by the shell varies between species and is much reduced in some aquatic turtles. Not all species can retract the head into the shell—some tuck their head along one shoulder under the edge of the shell.

Tortoises are slow animals, but some sea turtles can reach speeds of 19 mph (30 kph) when swimming, as a result of the modification of their forelimbs into flippers. Although they need to breathe air, many turtles are tolerant of low oxygen levels and can remain submerged for hours. Turtles have a slow metabolism and are generally long lived.

Some species are carnivores, others herbivores, but most turtles are omnivorous. Animal prey is either slow moving or ambushed as the turtle lies hidden. Food is broken up by the "beak," a sharp, keratinous jaw covering.

NESTING AND BREEDING

Turtles do not defend territories, but they can have extensive home ranges and may develop social hierarchies. Otherwise turtles often congregate on river banks or lakesides to bask or nest.

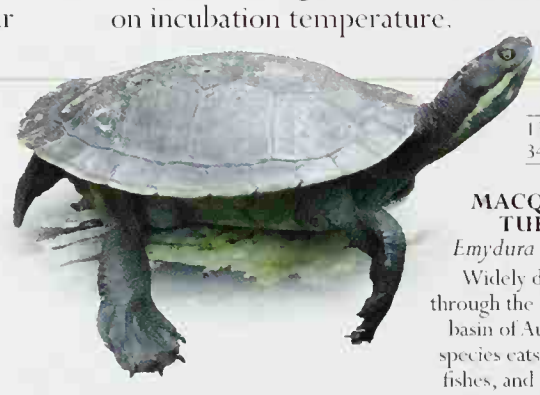
Both in water and on land, males of some species engage in elaborate courtship of females before copulation. Fertilization is internal and the females lay shelled eggs, like those of other reptiles and birds. These are spherical or elongated, with rigid or flexible shells. Clutches are laid in nests dug up by the female in terrestrial sites. Nearly all marine species come to land only to nest. In many species, but not all, the gender of the hatchlings depends on incubation temperature.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDER	TESTUDINES
FAMILIES	14
SPECIES	300

A green sea turtle hatchling enters the sea. Many of its breeding beaches are protected, but it remains endangered.

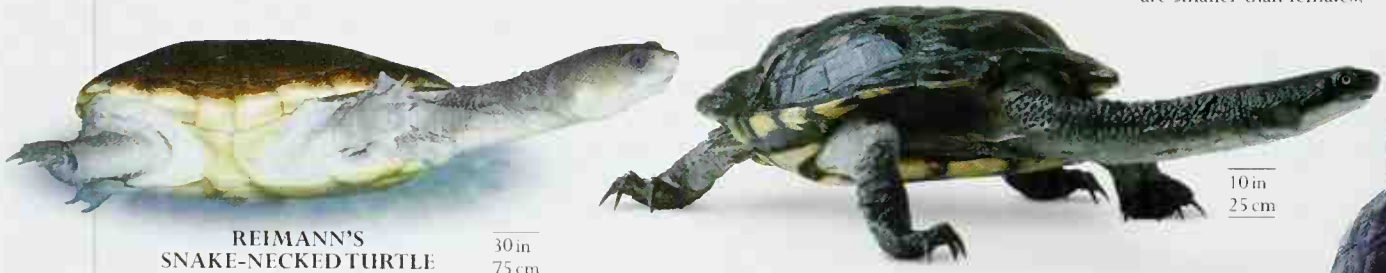
AUSTRO-AMERICAN SIDE-NECKED TURTLES

From South America and Australasia, the Chelidae include carnivorous and omnivorous species. Their characteristically long neck cannot be retracted, so it is turned sideways under the edge of the shell. They lay elongated eggs with leathery shells.



13½ in
34 cm

MACQUARIE TURTLE
Emydura macquarii
Widely distributed through the Murray River basin of Australia, this species eats amphibians, fishes, and algae. Males are smaller than females.



30 in
75 cm

REIMANN'S SNAKE-NECKED TURTLE
Chelodina reimanni
This turtle from New Guinea eats crustaceans and mollusks. When threatened, it tucks its large head under the side of its carapace.

10 in
25 cm

COMMON SNAKE-NECKED TURTLE
Chelodina longicollis
A shy freshwater turtle of Australia, this species has a long neck, which enables it to raise its head out of water and capture prey.

scalloped carapace with keel (central ridge)

20 in
50 cm

MATAMATA
Chelus fimbriatus
This South American turtle uses its unusual appearance as camouflage when ambushing prey, which it sucks into its mouth.

long snout

AFRICAN SIDE-NECKED TURTLES

Most of the Pelomedusidae are carnivorous and occupy freshwater habitats. When threatened, they can hide their head and neck beneath the edge of the shell. Found throughout Africa and Madagascar, they survive dry conditions by burying themselves in mud.

brown carapace

8 in
20 cm

scales on head resemble helmet

AFRICAN HELMETED TURTLE
Pelomedusa subrufa
Widespread in sub-Saharan Africa, this carnivorous turtle is highly social and often hunts in packs to bring down large prey.

BIG-HEADED TURTLE

The sole member of the Platysternidae, the big-headed turtle is an endangered species from forest streams in South and Southeast Asia. It forages in shallow streams, bottom-walking rather than swimming.

7 in
18 cm

BIG-HEADED TURTLE
Platysternon megacephalum
This small, carnivorous turtle has a flattened body, a very large head with powerful jaws, and a long tail.

AMERICAN SIDE-NECKED RIVER TURTLES

Closely related to African side-necked turtles, most species of the family Podocnemididae are found in tropical South America, except one in Madagascar. These are herbivorous turtles found in various freshwater habitats. They cannot retract their necks into their shells.

RED-HEADED AMAZON RIVER TURTLE
Podocnemis erythrocephala
This species is found in swamps of the Rio Negro region of the Amazon basin in South America.

12½ in
32 cm

SNAPPING TURTLES

Native to North and Central America, these large, aquatic turtles are noted for their aggression. The Chelydridae have rough shells and a powerful head, with heavy, crushing jaws. They are effective predators, ambushing a variety of animals, but they also eat plants.

22 in
55 cm

COMMON SNAPPING TURTLE
Chelydra serpentina
A robust turtle, it often lies in wait for prey half-buried in mud. It occupies freshwater habitats from eastern North America as far south as Ecuador.

massive head with strong jaws and sharp, pointed beak
tongue with wormlike lure
heavily built carapace with three rows of conical scutes

32 in
80 cm

ALLIGATOR SNAPPING TURTLE
Macrochelys temminckii
One of the largest freshwater turtles in the world, this North American species has a worm-shaped lure on its tongue to attract prey as it lies in wait.

SOFTSHELL TURTLES

These aquatic predators inhabit freshwater habitats in North America, Africa, and southern Asia. The shells of the Trionychidae are flattened and covered with leathery skin rather than keratinous scutes. They range in size from 10 in (25 cm) to over 3¼ ft (1 m) in shell length.

EASTERN SPINY SOFTSHELL
Apalone spinifera
A native of eastern North America, this species eats mainly insects and aquatic invertebrates.

INDIAN FLAP-SHELLED TURTLE
Lissemys punctata
This Indian turtle has a rear flap on either side of the plastron that protects the hind limbs when they are withdrawn into the body.

14 in
36 cm

CHINESE SOFT-SHELLED TURTLE
Pelodiscus sinensis
Hunted for its meat, this turtle of eastern Asia is rare in its native habitat, but tens of thousands are bred annually on farms.

PIG-NOSED TURTLE

The only species in the family Carettochelyidae, this turtle is an omnivore. Its carapace lacks hard scutes, but is still rigid. Its snout is adapted for breathing air while submerged.

PIG-NOSED RIVER TURTLE
Carettochelys insculpta
This nocturnal turtle is found in New Guinea and northern Australia. Like sea turtles, it has forelimbs modified as flippers for aquatic flight.

AMERICAN MUD AND MUSK TURTLES

These turtles from the New World emit a strong scent when threatened. The Kinosternidae tend to walk along the bottom of lakes and rivers, rather than swim, and are opportunistic omnivores. They lay elongated, hard-shelled eggs.

MISSISSIPPI MUD TURTLE
Kinosternon subrubrum
An omnivore, this freshwater turtle feeds on the bottom of slow, shallow watercourses in the southeastern US.

COMMON MUSK TURTLE
Sternotherus odoratus
This freshwater turtle from eastern North America is an omnivore. When threatened, it not only exudes a nauseating musk, but also bites.

LEATHERBACK SEA TURTLE

There is only one species in the Dermochelyidae. This turtle is capable of maintaining an elevated body temperature, which allows it to swim in cold waters. The shell has no scutes; the leathery skin covers a layer of insulating oily tissue.

LEATHERBACK SEA TURTLE
Dermochelys coriacea
Feeding mainly on jellyfish, this oceanic sea turtle is the world's largest turtle. It has a worldwide distribution that includes subarctic waters.

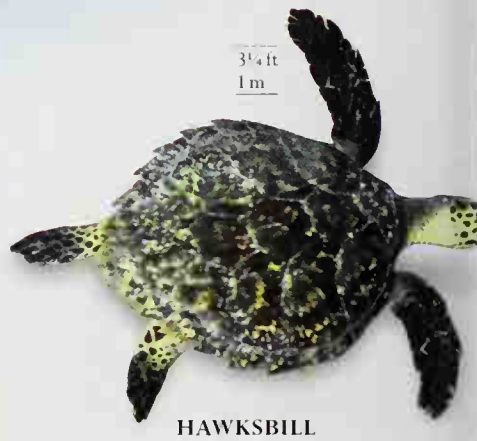
SEA TURTLES

Sea turtles occur throughout the world's oceans, mainly in coastal waters. They are highly adapted to the marine environment, with streamlined bodies and broad, paddlelike limbs. The Cheloniidae come to land to nest on beaches. Most species in this family are endangered.

LOGGERHEAD SEA TURTLE
Caretta caretta
This carnivorous species occurs in coastal waters worldwide but undertakes long migrations between feeding and nesting grounds.

GREEN SEA TURTLE
Chelonia mydas
This is the only sea turtle known to bask on land. It is found in temperate and tropical oceans worldwide and is a strict herbivore.

OLIVE RIDLEY SEA TURTLE
Lepidochelys olivacea
A species of mainly tropical, shallow coastal waters, this turtle eats a wide range of invertebrates and algae.



HAWKSBILL SEA TURTLE
Eretmochelys imbricata
This turtle uses its horny jaws to forage for mollusks and other prey. It is found in tropical oceans throughout the world.

POND TURTLES

These turtles range from being fully aquatic to fully terrestrial. Most of them are found in North America, but one species in this family comes from Europe. Diet varies between species, although many are herbivores. The Emydidae are often brightly colored and intricately marked.

FALSE MAP TURTLE
Graptemys pseudogeographica
This North American turtle occurs in freshwater habitats with abundant vegetation. Females are almost twice as large as males.

10½ in
27 cm

11 in
28 cm

RED-EARED SLIDER
Trachemys scripta elegans
This North American species is mainly herbivorous and is common in the pet trade. Its ability to colonize new habitats has allowed it to become widely established in Europe and Asia.

10½ in
27 cm

YELLOW-BELLIED SLIDER
Trachemys scripta scripta
Named for its habit of sliding into water when disturbed, this turtle of the southern US is a diurnal omnivore.

9 in
23 cm

SALTWATER TERRAPIN
Malaclemys terrapin
This is a diurnal species of brackish waters in eastern North America. It has powerful jaws adapted for eating crustaceans and mollusks.

10 in
25 cm

PAINTED TURTLE
Chrysemys picta
Widely distributed in North America, this small, freshwater turtle is active during summer. During winter, it lies torpid under water.

8 in
20 cm

CAROLINA BOX TURTLE
Terrapene carolina
Males of this North American species have evolved highly curved claws that help grip the female's domed shell while mating.

distinctively patterned shell

strong claws used for burrowing

5½ in
14 cm

ORNATE BOX TURTLE
Terrapene ornata
This is an omnivorous, terrestrial turtle of central North America. It digs burrows to escape extreme heat or cold.

5 in
13 cm

SPOTTED TURTLE
Clemmys guttata
Identifiable by its spots, this small turtle feeds on aquatic invertebrates and plants in the marshes of eastern North America.

10 in
26 cm

CHICKEN TURTLE
Deirochelys reticularia
This shy turtle of swamps in eastern North America extends its long neck to strike at crayfish and other prey.

8½ in
21 cm

EUROPEAN POND TURTLE
Emys orbicularis
Widespread in Europe, this is a highly aquatic turtle. It basks on logs or rocks, but rapidly dives into the water if disturbed.

5 in
13 cm

WOOD TURTLE
Glyptemys insculpta
This turtle occupies the damp forests in northeastern North America. Unusually, males and females perform an elegant dance together during courtship.

olive skin with irregular yellow spots

10 in
26 cm

BLANDING'S TURTLE
Emydoidea blandingii
Found mainly across the Great Lakes region of North America, this turtle is an omnivore and especially skilled at capturing crayfish.

15 in
38 cm

FLORIDA REDBELLY TURTLE
Pseudemys nelsoni
Restricted to Florida, this turtle lives in lakes and slow-moving streams. During courtship, the male caresses the female's head with his forelimbs.

16 in
40 cm

RED-BELLIED TURTLE
Pseudemys rubriventris
Restricted to the northeastern US, this omnivorous, diurnal species prefers large, deep bodies of water. Females are larger than males.

ALDABRA GIANT TORTOISE

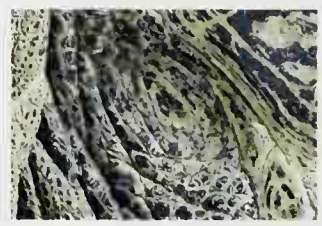
Aldabrachelys gigantea

The last remaining species of giant tortoise on islands in the Indian Ocean, the Aldabra giant tortoise can weigh over 660 lb (300 kg). Although resident on three islets of the Aldabra atoll, over 90 percent of the tortoises live on Grande-Terre—the largest islet by far—despite the scarcity of water and inadequate supply of vegetation. Poor conditions there have inhibited the growth of individual tortoises, and many do not reach sexual maturity. However, they are highly social, more so than the larger tortoises on other islets. Males are larger than females, but courtship is a gentle affair. Their eggs are buried underground, and hatch in the rainy season. The whole population is vulnerable to natural disasters and rising sea levels.

SIZE 4 ft (1.2 m)
HABITAT Grassy areas
DISTRIBUTION Aldabra, Indian Ocean
DIET Vegetation

^ **LEATHERY VISAGE**
The skin is tough, leathery, and—depending on islet—either gray or brown. The skin is creased into folds around the neck. If it senses danger, the tortoise pulls its head back inside its shell.

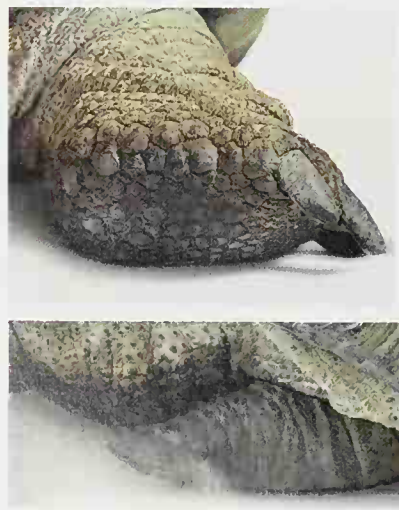
< **HORNY BEAK**
The tortoise's large mouth contains no teeth. It cuts vegetation with its sharp, horny beak, takes it into the mouth with its tongue, and swallows it whole.



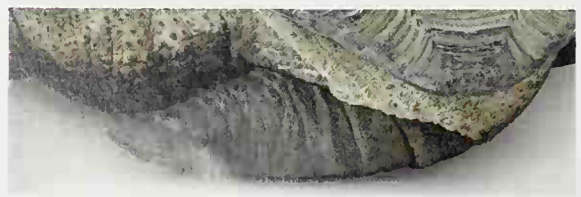
< **EAR**
Tortoises have no external ear flap; so the eardrum is situated in a hollow.

< **EYE**
The eye is relatively large and has a well-developed eyelid. Tortoises can see in color, particularly in the red and yellow parts of the spectrum; this probably helps them find colorful fruit.

^ **FORELEG**
The front limbs are cylindrical in shape, and longer than the hind limbs. This allows the tortoise to raise its body well above the ground as it walks. The legs are covered in large, rough scales.



< **DIGGING CLAWS**
Tortoises have sturdy, elephant-like hind limbs, with five claws on each foot. Females have larger claws than males, which they use when excavating a nesting site.



< **TAIL**
The giant tortoise has a short tail, and can tuck it to one side under the back of the carapace. Males have longer tails than females.

scutes on the upper shell show growth rings

MADE TO LAST ∨
Compared to giant tortoises from the Galapagos, this species has a more rounded head, a pointed snout, and a smiling mouth. It can live for more than a hundred years.

POND AND RIVER TURTLES

Found both in the Old and New Worlds, the Geoemydidae are freshwater and terrestrial turtles, ranging in adult shell length from 5½ to 20 in (14–50 cm). They vary in their dietary preferences from being herbivorous to carnivorous. Many exhibit sexual dimorphism, with females being larger than males.

9 in
23 cm

BROWN LAND TURTLE
Rhinoclemmys annulata

A herbivorous tortoise, this species lives in tropical forests of Central America. It is mainly active in the morning and after rains.

12 in
30 cm

GOLDEN COIN TURTLE
Cuora trifasciata

This is a carnivorous turtle from southern China. Its name derives from its value in the illegal wildlife market. Its use in traditional medicine threatens its survival.

pronounced spinal keel

6½ in
17 cm

yellow stripes behind eyes

YELLOW-MARGINATED BOX TURTLE
Cuora flavomarginata

An omnivore of China's rice paddies, this species avoids deep water and spends hours basking on land.

5 in
13 cm

ASIAN LEAF TURTLE
Cyclemys dentata

This omnivorous turtle is found in slow-moving waters in Southeast Asia. It defends itself by emitting a foul-smelling liquid.

5 in
13 cm

BLACK-BREASTED LEAF TURTLE
Geoemyda spengleri

An inhabitant of wooded mountains in southern China, this turtle eats small invertebrates and fruit. Its carapace is rectangular, keeled, and spiky.

TORTOISES

Found in the Americas, Africa, and southern Eurasia, members of the family Testudinidae can reach great sizes. They have solid domed shells into which they can retract their heads. Fully terrestrial, tortoises are characterized by elephantine limbs. They lay hard-shelled eggs.

12 in
30 cm

DESERT TORTOISE
Gopherus agassizii

This tortoise lives in small burrows in deserts of southwestern North America. Mainly vegetarian, it sometimes preys on animals.

13 in
33 cm

ELONGATED TORTOISE
Indotestudo elongata

Found in tropical Southeast Asia, this tortoise eats fruit and carrion. It hides in moist leaf litter when the weather is dry.

16 in
40 cm

SERRATED HINGE-BACK TORTOISE
Kinixys erosa

This is an omnivorous species found in swamps in tropical West Africa. Older tortoises develop hinges in the rear of their carapaces.

16 in
40 cm

RADIATED TORTOISE
Astrochelys radiata

Restricted to southern Madagascar, this endangered species eats mainly plants and is active during the early part of the day.

28 in
70 cm

RED-FOOTED TORTOISE
Chelonoidis carbonaria

Although known to eat carrion, this tortoise is mainly vegetarian. It is found in a variety of habitats of northeastern South America.

highly domed scutes

INDIAN STARRED TORTOISE
Geochelone elegans

Found in dry areas of India and Sri Lanka, this herbivorous species mates and breeds in the monsoon season.

15 in
38 cm

7 in
18 cm

PANCAKE TORTOISE
Malacochersus tornieri
Found in East Africa, this omnivorous species inhabits rocky areas. Its flat shape allows it to hide in cracks.

growth rings on the carapace of juveniles

4 ft
1.2 m

ALDABRA GIANT TORTOISE
Aldabrachelys gigantea
Restricted to the Aldabra atoll in the Indian Ocean, this large herbivore is able to drink through its nostrils.

large forelimb

flattened scute

GALAPAGOS TORTOISE
Chelonoidis elephantopus
One of the world's largest tortoises, this mainly vegetarian species has 11 subspecies, from different islands in the Galapagos archipelago.

jaw with sharp cutting edge for eating vegetation

4 ft
1.2 m

7½ in
19 cm

HERMANN'S TORTOISE
Testudo hermanni
This herbivorous species inhabits dry forests of coastal Italy and southern France. It hibernates during the cold winter months.

11 in
28 cm

STEPPES TORTOISE
Testudo horsfieldii
A herbivore from the dry deserts and steppes of Central Asia, this species escapes the daytime heat by sheltering in burrows.

TUATARAS

Superficially like a lizard, New Zealand's tuatara belongs to a far more ancient order of reptiles. Its closest relatives became extinct 100 million years ago.

The tuatara has many anatomical features that set it apart from lizards. Most striking are its wedge-shaped "teeth"—actually serrations of the jawbone. The upper jaw has a double row that fits over a single row on the lower jaw.

Tuataras are very long lived, but are vulnerable to introduced ground predators. Inhabiting coastal forests, they are active at low body temperatures and emerge from their burrows at night to hunt for invertebrates, and birds' eggs and chicks. Males are territorial and nesting is communal. Eggs take up to four years to form and are incubated for 11 to 16 months before hatching. Incubation temperature determines the sex of the hatchlings.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDER	RHYNCHOCEPHALIA
FAMILIES	1
SPECIES	2

TUATARA

Often portrayed as "living fossils," the Sphenodontidae are modern representatives of reptiles that coexisted with dinosaurs. These primitive species are found only on offshore islands of New Zealand.

crest used for display

TUATARA
Sphenodon punctatus
This reptile has clawed limbs to dig burrows. It can shed its tail to escape predators. The male uses its dorsal crest for display.

23½ in
60 cm

powerful clawed limbs

LIZARDS

Typically, lizards have four legs and a long, thin tail, but there are also many legless species. They have scaly skin and firm jaw articulation.

All lizards are ectothermic, obtaining heat energy from the environment. Although seen as predominately tropical or desert animals, they have a global distribution; lizards are found from beyond the Arctic Circle in Europe to the tip of South America. Highly adaptable, they occupy a wide range of terrestrial habitats with many being arboreal or rock dwelling. Many legless species are adapted for burrowing, a few lizards are effective gliders from trees, and others are semiaquatic, including a marine species on the Galapagos Islands.

STRATEGIES FOR SURVIVAL

Lizards range in length from about ½ in (1.5 cm) to 9¾ ft (3 m) in the case of the Komodo dragon, but the majority are between 4 and 12 in (10–30 cm). Although most are carnivores, around two percent of species are primarily herbivorous. Many lizards are prey for other carnivores. Their defense mechanisms depend on agility, camouflage, and bluff. Many species are able to shed their tail to distract the attention of predators as they escape. The tail grows back. In some families of lizard, the skin can change color. This ability can be used for camouflage or for sexual or social signaling. Unusually, in many lizards the pineal gland on the top of the head acts as a light-sensitive "third eye."

VARIED LIFESTYLES

Although some species are solitary, many lizards have complex social structures, with the males maintaining their territories through visual signals. Many species lay eggs in underground nests, while others retain the eggs in the oviduct until hatching. There are also truly viviparous species, in which the mother provides nutrition via a placenta. Males have paired hemipenes—sexual organs used for internal fertilization—although some species are parthenogenetic, with females reproducing without the participation of a male. Some lizards tend their eggs during incubation but very few exhibit any maternal care of the hatchlings.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDER	SQUAMATA
FAMILIES (LIZARDS)	27
SPECIES	4,560

DEBATE

SQUAMATA: AN ALL-INCLUSIVE ORDER

Traditionally, lizards and snakes were considered two distinct groups, but modern genetic research makes it clear that they are not. Primitive squamates (scaled reptiles) were lizardlike animals that arose in the mid-Jurassic. Available evidence suggests that snakes evolved from lizards during the mid-Cretaceous. By this time various families of lizards had branched off on their own evolutionary course. Some lizard families are thus closer to snakes than they are to other lizards. Of living lizards, the monitors are thought to be those most closely related to snakes.

CHAMELEONS

Restricted to the Old World, the members of the family Chamaeleonidae have long limbs with grasping feet and a prehensile tail for gripping branches—an adaptation for life in trees. Their eyes are capable of moving independently in any direction to locate insects or small vertebrates. They catch their prey with a long, sticky tongue that shoots out from the mouth. Their ability to change color is for display and camouflage. Many species are threatened with extinction.

3¼ in
8 cm

BEARDED PYGMY-CHAMELEON
Rieppeleon brevicaudatus
This unusual, small chameleon is from East Africa. Drab coloration and patterning along its body allow it to resemble a dead leaf.

28 in
70 cm

PARSON'S CHAMELEON
Calumma parsonii
The largest chameleon in the world, this species is restricted to Madagascar. It hunts invertebrates in the canopy of montane forests.

prehensile tail

12 in
30 cm

JACKSON'S CHAMELEON
Chamaeleo jacksonii
This diurnal, arboreal species is found in East Africa. The male is identifiable by the three horns on its snout, which are for display.

green skin coloration sometimes changes to brown

12 in
30 cm

MEDITERRANEAN CHAMELEON
Chamaeleo chamaeleon
This chameleon spends its time in bushes searching for insects. It is found in North Africa and around the Mediterranean.

dorsal spines

grasping, four-toed feet

20 in
51 cm

GIANT SPINY CHAMELEON
Furcifer verrucosus
This large chameleon is a native of the humid, [illegible] forests of Madagascar. A shy species, it relies [illegible] insect prey.

22 in
56 cm

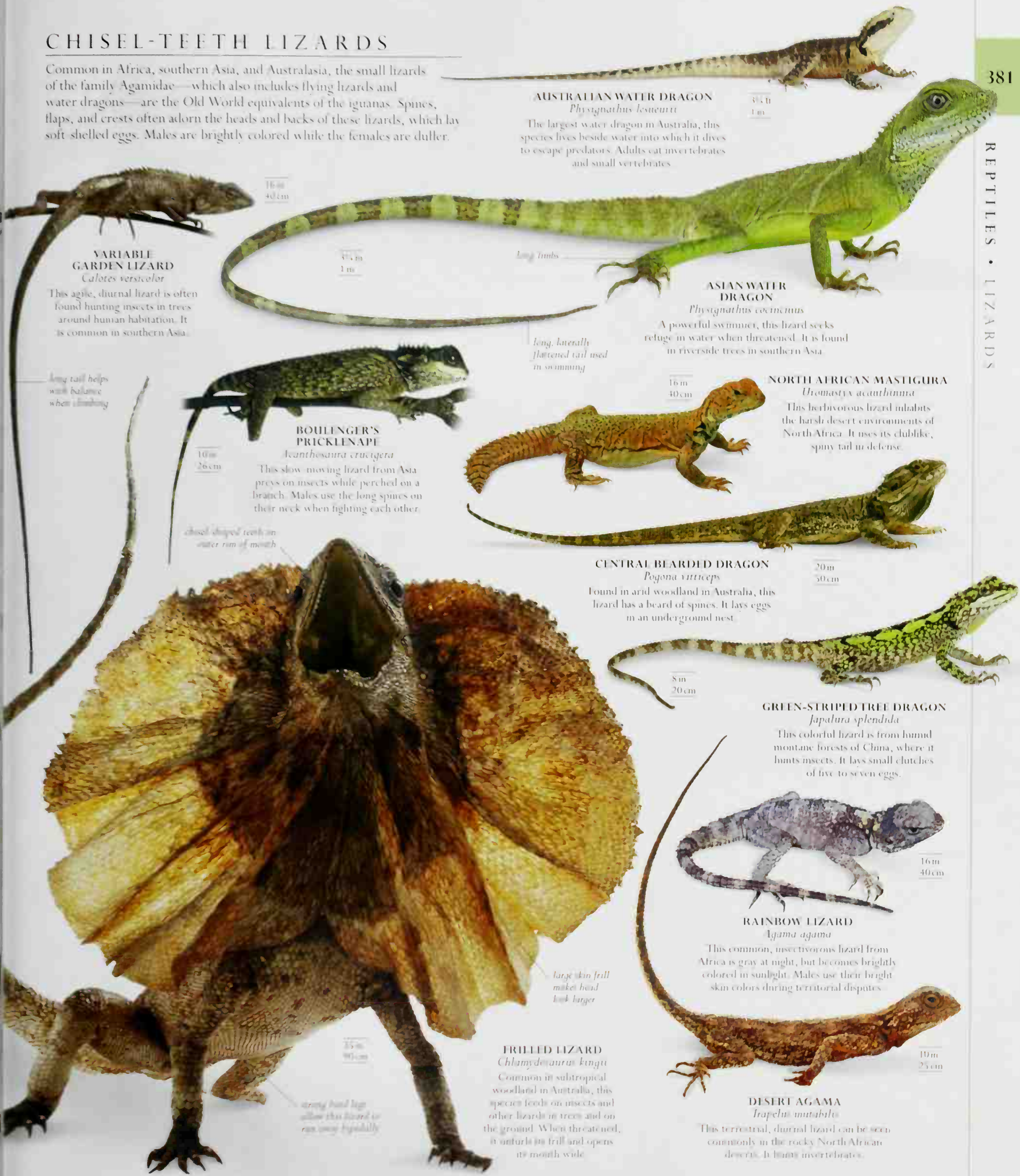
PANTHER CHAMELEON
Furcifer pardalis
Found only in dry forests in Madagascar, this lizard hunts insects in trees by stealth. Males are highly territorial.

23½ in
60 cm

VEILED CHAMELEON
Chamaeleo calyptratus
This species is from the southern coast of the Arabian Peninsula. Males have a large casque on the head, while females have a smaller one.

CHISEL-TEETH LIZARDS

Common in Africa, southern Asia, and Australasia, the small lizards of the family Agamidae—which also includes flying lizards and water dragons—are the Old World equivalents of the iguanas. Spines, flaps, and crests often adorn the heads and backs of these lizards, which lay soft-shelled eggs. Males are brightly colored while the females are duller.


AUSTRALIAN WATER DRAGON
Physignathus lesueurii
The largest water dragon in Australia, this species lives beside water into which it dives to escape predators. Adults eat invertebrates and small vertebrates.
35 in
1 m
VARIABLE GARDEN LIZARD
Calotes versicolor
This agile, diurnal lizard is often found hunting insects in trees around human habitation. It is common in southern Asia.
16 in
40 cm
35 in
1 m
long limbs
ASIAN WATER DRAGON
Physignathus cocincinus
A powerful swimmer, this lizard seeks refuge in water when threatened. It is found in riverside trees in southern Asia.
long, laterally flattened tail used in swimming
long tail helps with balance when climbing
BOULENGER'S PRICKLENAPE
Acanthosaura crucigera
This slow-moving lizard from Asia preys on insects while perched on a branch. Males use the long spines on their neck when fighting each other.
10 in
26 cm
NORTH AFRICAN MASTIGURA
Uromastyx acanthinura
This herbivorous lizard inhabits the harsh desert environments of North Africa. It uses its clublike, spiny tail in defense.
16 in
40 cm
chisel-shaped teeth on outer rim of mouth
CENTRAL BEARDED DRAGON
Pogona vitticeps
Found in arid woodland in Australia, this lizard has a beard of spines. It lays eggs in an underground nest.
20 in
50 cm
GREEN-STRIPED TREE DRAGON
Japalura splendida
This colorful lizard is from humid montane forests of China, where it hunts insects. It lays small clutches of five to seven eggs.
8 in
20 cm
RAINBOW LIZARD
Agama agama
This common, insectivorous lizard from Africa is gray at night, but becomes brightly colored in sunlight. Males use their bright skin colors during territorial disputes.
16 in
40 cm
large skin frill makes head look larger
FRILLED LIZARD
Chlamydosaurus kingii
Common in subtropical woodland in Australia, this species feeds on insects and other lizards in trees and on the ground. When threatened, it unfurls its frill and opens its mouth wide.
35 in
90 cm
strong hind legs allow this lizard to run away bipedally
DESERT AGAMA
Trapelus mutabilis
This terrestrial, diurnal lizard can be seen commonly in the rocky North African deserts. It hunts invertebrates.
10 in
25 cm

PANTHER CHAMELEON

Furcifer pardalis

This large chameleon is endemic to Madagascar, off the east coast of southern Africa, and has also been introduced to Mauritius and Réunion. This species lives in trees in humid scrubland, and its feet are so well adapted for grasping branches that it is difficult for the lizard to walk across a flat surface. Active during the day, it moves slowly through the branches to hunt its insect food by stealth. When it spots its next meal, the chameleon focuses on its victim with both eyes, then shoots out its long tongue to grasp the insect and pull it back into its large mouth. The chameleon's uncanny ability to change color is an indicator of mood and social status only, and is not used for camouflage. When faced with a rival, it rapidly inflates its body and changes color, putting on a display of dominance that is usually enough to decide a dispute.

SIZE 16–22 in (40–56 cm)
HABITAT Trees in humid scrub
DISTRIBUTION Madagascar
DIET Arthropods, crustaceans

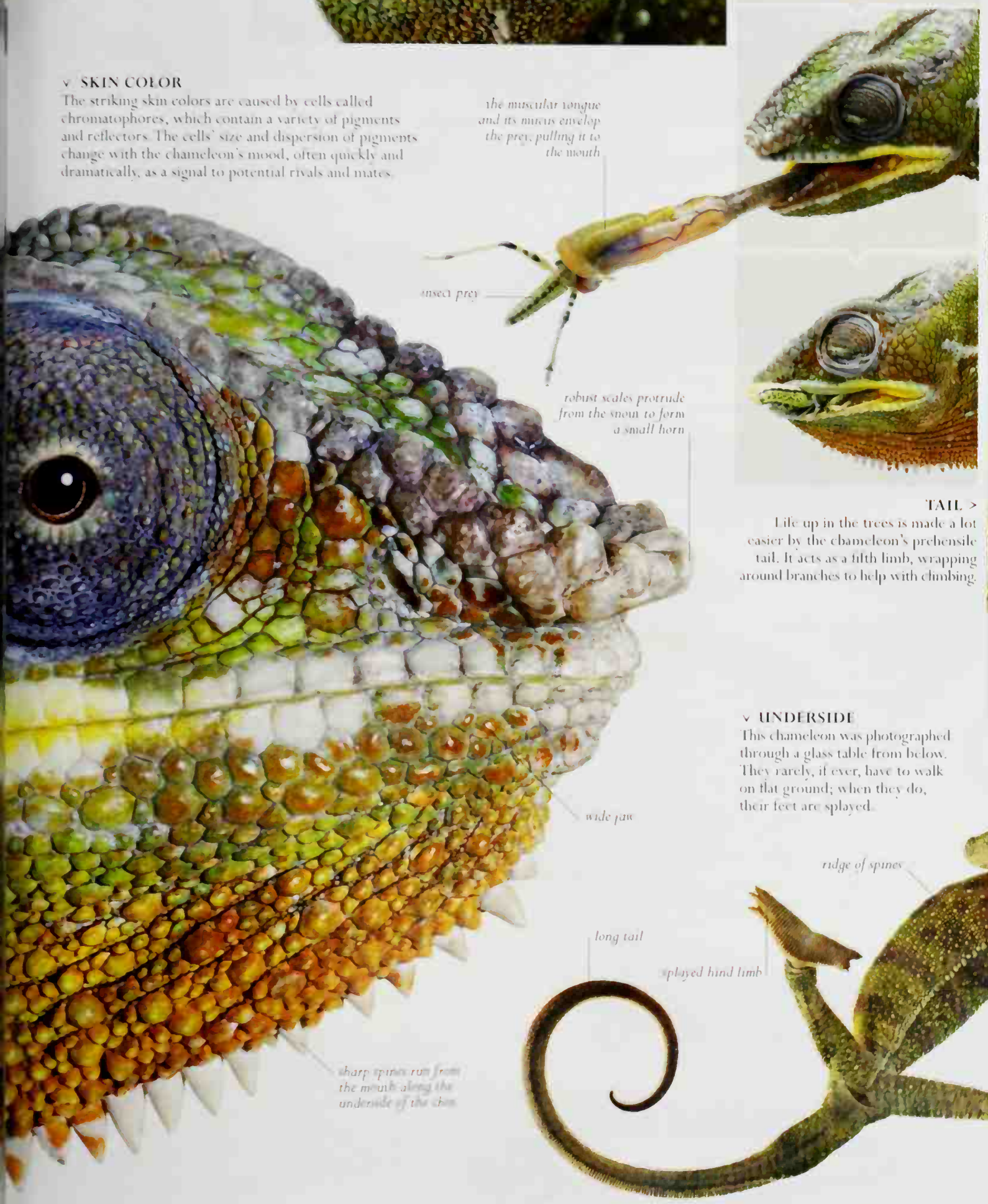
a ridge of protective spines runs along the midline of the back

casque, or bony shield, at the back of the head

EYES >
Uniquely, chameleons are able to move each eye independently of the other. With eyes pointing in different directions, the chameleon can look out for predators while also searching for prey. Chameleons do not have ears.

< TONGUE
The tongue is very long and is fired from the mouth at great speed. This allows the chameleon to seize unsuspecting prey from some distance away.

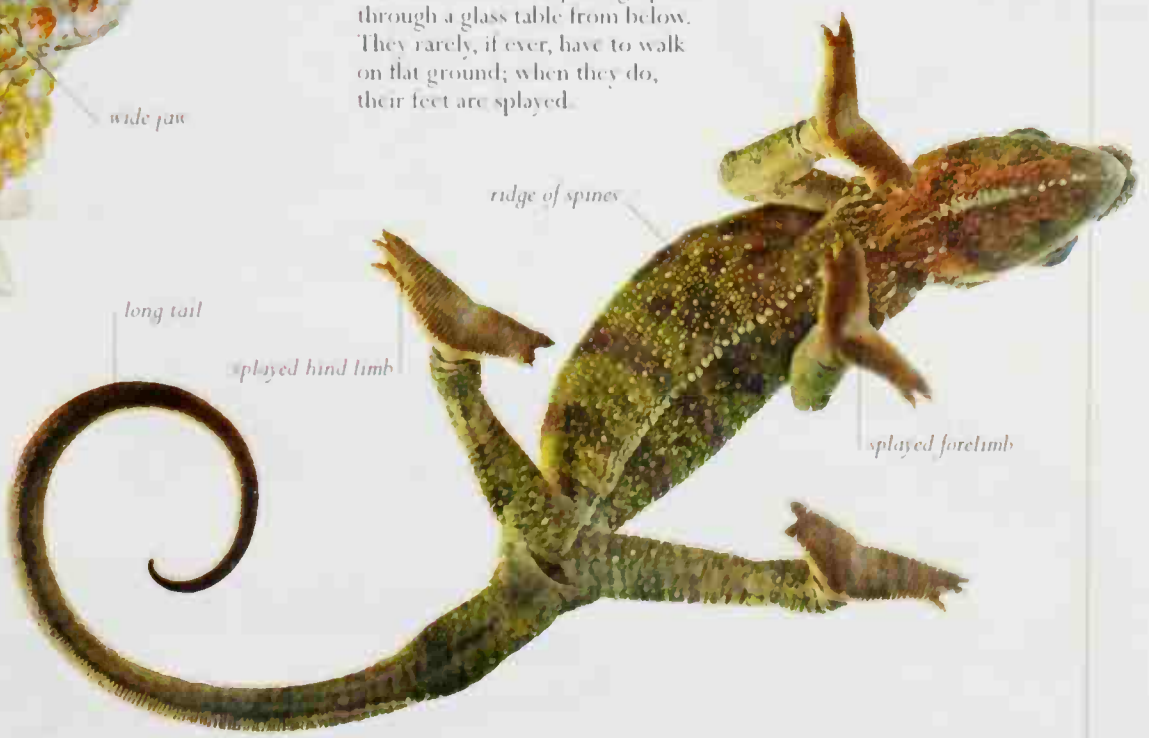
v SKIN COLOR
The striking skin colors are caused by cells called chromatophores, which contain a variety of pigments and reflectors. The cells' size and dispersion of pigments change with the chameleon's mood, often quickly and dramatically, as a signal to potential rivals and mates.


the muscular tongue and its mucus envelop the prey, pulling it to the mouth
insect prey
robust scales protrude from the snout to form a small horn
wide jaw
sharp spines run from the mouth along the underside of the chin

v CLAWED FEET
The chameleon's toes are clawed, and arranged into groups of two and three on opposite sides of the foot. This enables the animal to grip any branch tightly.

TAIL >
Life up in the trees is made a lot easier by the chameleon's prehensile tail. It acts as a fifth limb, wrapping around branches to help with climbing.

v UNDERSIDE
This chameleon was photographed through a glass table from below. They rarely, if ever, have to walk on flat ground; when they do, their feet are splayed.



GECKOS

Widely distributed in the tropics and subtropics, the Gekkonidae number over 1,000 species in 100 genera. They are noted for being very vocal and for their ability to climb smooth surfaces. Many lay hard-shelled eggs, while others lay soft-shelled eggs. Some species are viviparous.

WESTERN BANDED GECKO
Coleonyx variegatus
4¾ in
12 cm

This terrestrial gecko hunts invertebrates in the deserts of the western US. Unlike many geckos, it has moveable eyelids.

KUHL'S FLYING GECKO
Ptychozoon kuhli
8 in
20 cm

This gecko's webbed toes and skin flaps help break its fall as it parachutes from trees in the rain forests of Southeast Asia.

8¼ in
21 cm

COMMON LEOPARD GECKO
Eublepharis macularius

Originally from southern central Asia, this gecko is a popular pet, which has been bred for different markings and colors.

6 in
15 cm

MOORISH GECKO
Tarentola mauritanica

Common around the Mediterranean, this agile gecko preys on insects. It lives on rock faces but often enters houses.

8 in
20 cm

WONDER GECKO
Teratoscincus scincus

To defend itself, this Central Asian species waves its tail slowly, causing a row of large scales on the tail to rub together, making a hissing sound.

10 in
25 cm

MADAGASCAR DAY GECKO
Phelsuma madagascariensis

This colorful diurnal species is typically found on trees. Like many geckos, it lays hard-shelled eggs that stick to a branch.

10 in
25 cm

AFRICAN FAT-TAILED GECKO
Hemitheconyx caudicinctus

Common in the western Sahara, this species has a tail that stores fat. It lacks the adhesive foot pads of many other geckos.

16 in
40 cm

TOKAY
Gekko gecko

Named after its harsh "to-kay" call, this large gecko from Southeast Asia often lives in houses.

4 in
10 cm

MEDITERRANEAN GECKO
Hemidactylus turcicus

Often betrayed by its mewing cry, this small European gecko is common in houses, where it hunts insects attracted to lights.

13½ in
34 cm

RING-TAILED GECKO
Cyrtodactylus louisiadensis

Found in New Guinea, this large, nocturnal gecko feeds aggressively on invertebrates and small frogs found on the ground.

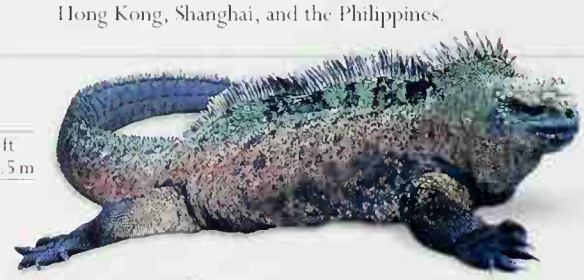
6 in
15 cm

ASIAN SPINY GECKO
Hemidactylus brookii

This gecko lives in close proximity to humans. Native to northern India, it now also occurs in Hong Kong, Shanghai, and the Philippines.

IGUANAS

Largely confined to the Americas, the Iguanidae number nearly 30 species in 8 genera. They are diverse in color. Most are diurnal, carnivorous predators, although larger species are herbivorous. They all lay eggs.



2¼–5 ft
0.7–1.5 m

MARINE IGUANA
Amblyrhynchus cristatus

Native to the Galapagos Islands, this aquatic lizard is well adapted to feeding on underwater algae. Nasal glands help remove salt.

35 in
90 cm

BLACK IGUANA
Ctenosaura similis

This gregarious species from Central America lives in colonies with a dominant male. Although usually herbivorous, it sometimes eats small lizards.

6½ ft
2 m

GREEN IGUANA
Iguana iguana

Widespread in Central and South America, this large iguana is herbivorous. Males defend their territory by vigorously nodding their heads to display dominance.

HELMETED LIZARDS

Nine species of arboreal lizards from Central and South America constitute the family Corytophanidae. They are closely related to the iguanas. All species have well-developed head crests. Long legs and tails allow these lizards to run at high speeds to evade predators.

sail-like dorsal crest
bright orange iris
long legs
long tail aids balance when climbing or running
hard, conelike casque at rear of head
slender green feet and legs

GREEN BASILISK
Basiliscus plumifrons
Native to Central American rain forests, this species inhabits riverbanks. The crests on its head, back, and tail are supported by bony spines.

26 in
65 cm

HELMETED IGUANA
Corytophanes cristatus
This Central American iguana lives on a diet of large arthropods. By feeding infrequently, it minimizes the time it spends in the open or is conspicuous to predators.

13½ in
34 cm

EASTERN CASQUE-HEADED IGUANA
Laemanctus longipes
This large, insectivorous species lives in small groups of one male and two to three females. It is native to Central America.

28 in
70 cm

NORTH AMERICAN SPINY LIZARDS

Restricted to North and Central America, the Phrynosomatidae are a diverse family of lizards that prefer arid environments and hunt insects. They are generally small, dull colored, and spiny. Most lay eggs, but those living at high altitudes are viviparous.

GREEN SPINY IGUANA
Sceloporus malachiticus
This diurnal, arboreal lizard from Central America has stiff, keeled scales, giving it a spiny appearance.

8 in
20 cm

COLORADO DESERT FRINGE-TOED LIZARD
Uma notata
Closable nostrils and ear flaps, overlapping jaws, and interlocking eyelids help protect this desert-living species as it burrows in sand.

3¼ in
8 cm

DESERT HORNED LIZARD
Phrynosoma platyrhinos
This lizard of North American deserts primarily eats ants. Its flattened body is an adaptation to maximize heat absorption while basking in the sun.

6 in
15 cm

ANOLES

Most anoles come from around the Caribbean. A diverse group, the Polychrotidae are typically small, arboreal, and insectivorous. Although often green or brown, they change skin color according to mood and environment. Both sexes aggressively defend their territories.

KNIGHT ANOLE
Anolis equestris
The largest anole, this species is restricted to Cuba. Adhesive pads on its toes enable it to scale smooth walls.

20 in
50 cm

CAROLINA ANOLE
Anolis carolinensis
Males of this species show their dominance by bobbing their heads and flaring their brightly colored throat fan.

8 in
20 cm

FLAP-FOOTED LIZARDS

All lizards of this group have elongated bodies, no front limbs, and much-reduced hind limbs. Restricted to Australasia, the 36 species in the family Pygopodidae hunt insects by burrowing or on the surface. They are related to geckos and lay soft-shelled eggs.

FRASER'S DELMA
Delma fraseri
This insectivorous, Australian lizard inhabits spinifex grassland. It is well adapted to moving through the stiff blades of grass.

4¾ in
12 cm

COMMON SCALY FOOT
Pygopus lepidopodus
Snakelike in appearance, this lizard is widespread in Australia. It is a diurnal predator of insects and tunnel-inhabiting spiders.

8¼ in
21 cm

BURTON'S SNAKE-LIZARD
Lialis burtonis
Native to Australia, this lizard has an elongated, wedge-shaped snout that it uses to grasp skinks, which it consumes whole.

23⅝ in
60 cm

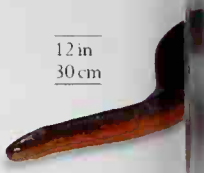
SKINKS

Distributed worldwide, the Scincidae are a diverse group of 1,400 species. While many are active diurnal predators, several others are nocturnal, limbless, burrowing lizards. They use chemical as well as visual communication. Although typically oviparous, many species are viviparous.

FIRE SKINK
Lepidothyris fernandi
This insectivorous skink is native to humid, forested areas of West Africa. Its attractive coloration makes it a popular lizard to keep in captivity.

EMERALD SKINK
Lamprolepis smaragdina
Native to islands of the western Pacific, this arboreal lizard preys on insects on bare tree trunks.

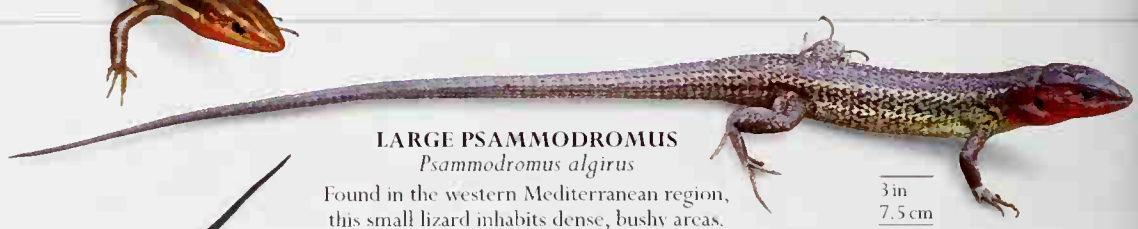
FIVE-LINED SKINK
Plestiodon fasciatus
This North American skink coils around its eggs to protect them during incubation. It prefers woodland and feeds on ground-living insects.



PERCIVAL'S LANCE SKINK
Acontias percivali
This legless African skink burrows through leaf litter to hunt its invertebrate prey. It gives birth to up to three live young.

WALL AND SAND LIZARDS

Lizards of the family Lacertidae are found in a wide variety of habitats throughout the Old World. They are active predators and have complex social systems, with males defending their territory. Almost all species lay eggs. These lizards typically have large heads.

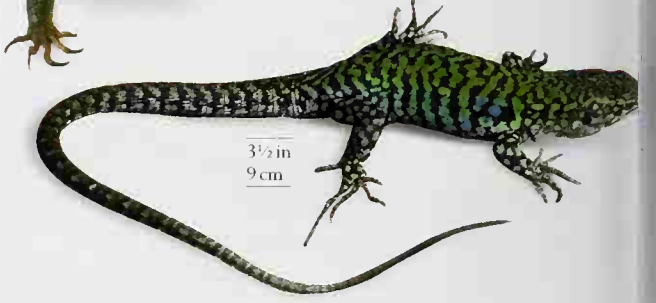


LARGE PSAMMODROMUS
Psammodromus algirus
Found in the western Mediterranean region, this small lizard inhabits dense, bushy areas. During breeding, males develop a red patch on their throat.

OCELLATED LIZARD
Timon lepidus
The largest European member of the family, this lizard lives in dry, bushy places. It eats insects, eggs, and small mammals.

VIVIPAROUS LIZARD
Zootoca vivipara
Found throughout Europe and up to 9,900 ft (3,000 m) in the Alps, this ground-dwelling lizard lives in a variety of habitats. It gives birth to live young.

FRINGE-TOED LIZARD
Acanthodactylus erythrurus
Found in the Iberian Peninsula and North Africa, this species has fringes of spiny scales on its toes that enable it to cross over loose sand.



ITALIAN WALL LIZARD
Podarcis siculus
A ground-living species, found around the northern Mediterranean, this lizard inhabits grassy places and often lives in close proximity to humans.

GRAN CANARIA GIANT LIZARD
Gallotia stehlini
This large species is restricted to the shrubland of Grand Canary Island. It is diurnal and herbivorous.

WHIPTAILS AND RACERUNNERS

These fast-running American lizards occupy a range of habitats. Smaller species of the Teiidae are insectivorous but larger ones are carnivorous. All 120 species are oviparous, although many whiptails are all-female and reproduce parthenogenetically, laying viable, fertile eggs without mating.

AMAZON RACERUNNER
Ameiva ameiva
Powerful jaws allow this South American species to feed on small vertebrates and insects that it catches in open terrestrial habitats.

RED TEGU
Tupinambis rufescens
This large species of the arid regions of central South America is an active predator and scavenger, but is also known to eat plants.

BERBER SKINK
Eumeces schneideri
This diurnal skink eats insects, small vertebrates, and carrion. It is native to North Africa and the deserts of southwestern Asia.

16 in
40 cm

MANY-LINED SUN SKINK
Eutropis multifasciata
Found in southern Asia, this lizard hunts insects in sunlit clearings within forests. It gives birth to live young.

14 in
35 cm

SANDFISH SKINK
Scincus scincus
This insectivorous, North African skink is named for its habit of diving into loose sand to evade predators and keep its body cool.

8 in
20 cm

6 in
15 cm

LITTLE BROWN SKINK
Scincella lateralis
Living in leaf litter in woodland, this North American skink hunts insects. A female can store sperm to fertilize her eggs.

EASTERN BLUE-TONGUED SKINK
Tiliqua scincoides
Characterized by its eponymous blue tongue, this Australian skink is a diurnal omnivore. It bears live young.

28 in
72 cm

14½ in
37 cm

SOLOMON ISLANDS SKINK
Corucia zebrata
This is the world's largest skink. It is strictly arboreal, has a prehensile tail, and is herbivorous. It lives in groups.

PLATED LIZARDS

There are 32 species of plated lizards. All are from sub-Saharan Africa and lay eggs. They have cylindrical bodies with well-developed legs for hunting insects in rocky areas and the savanna. Solitary in nature, the Gerrhosauridae are often aggressive to other members of their species.

19 in
48 cm

ROUGH-SCALED PLATED LIZARD
Gerrhosaurus major
This omnivorous species is widely distributed in the savanna of East Africa. It occupies crevices in rocky outcrops or termite nests.

14 in
36 cm

MADAGASCAN GIRDLED LIZARD
Zonosaurus madagascariensis
This insectivorous lizard is native to Madagascar. It prefers to be solitary, and feeds on the ground in open, dry habitats.

GIRDLED LIZARDS

Limited to southern and eastern Africa, the Cordylidae are named for the rings of spiny scales that encircle their tail. Their flattened body has limited space for live young or eggs. In viviparous species, this restricts litter size; oviparous species lay only two eggs.

CAPE GIRDLED LIZARD
Cordylus cordylus
Endemic to southern Africa, this lizard lives in dense colonies. Adults are aggressive, and form social hierarchies under a dominant male.

8½ in
21 cm

spiny scales

MICROTEIID LIZARDS

There are 165 species of the Gymnophthalmidae in tropical South America. Generally small, they are characterized by large scales on their back. These are diurnal and secretive insectivorous lizards and their dull coloration provides camouflage in leaf litter. Most species lay eggs.

BROMELIAD LIZARD
Anadia ocellata
An arboreal species found in Central America, the bromeliad lizard hunts insects and takes refuge in foliage.

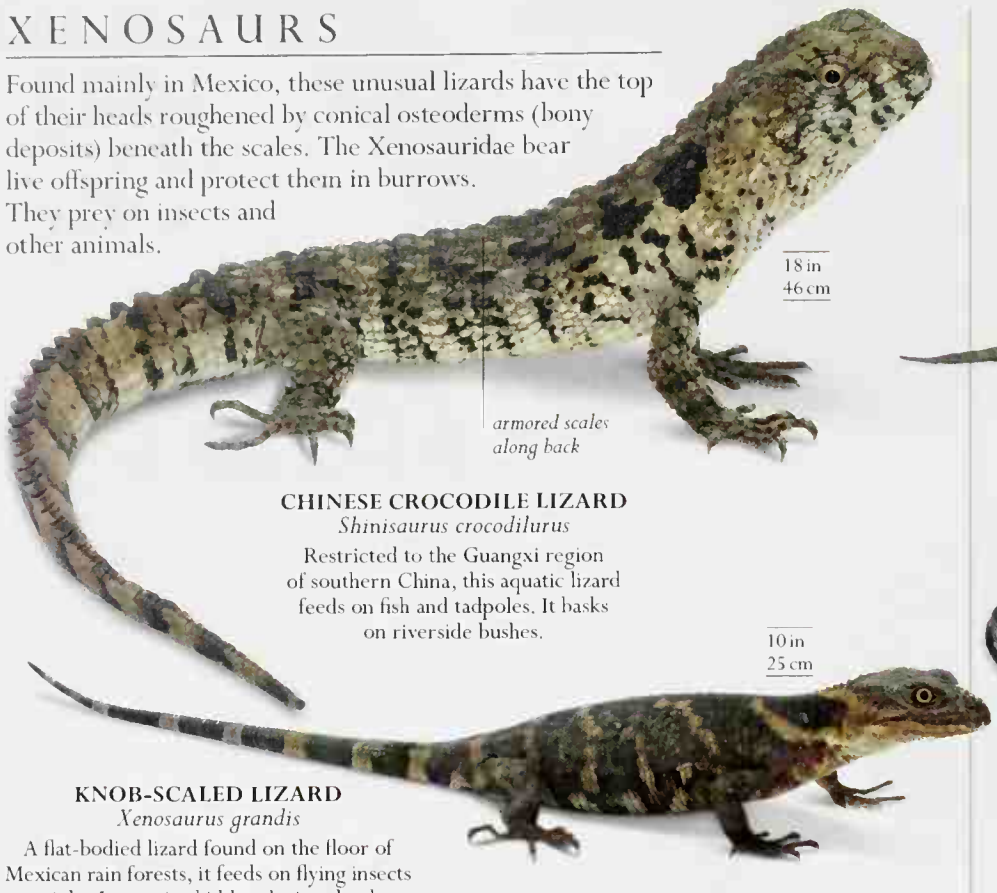
3¼ in
8 cm

muscular body

glossy head scales

XENOSAURS

Found mainly in Mexico, these unusual lizards have the top of their heads roughened by conical osteoderms (bony deposits) beneath the scales. The Xenosauridae bear live offspring and protect them in burrows. They prey on insects and other animals.



CHINESE CROCODILE LIZARD
Shinisaurus crocodilurus
Restricted to the Guangxi region of southern China, this aquatic lizard feeds on fish and tadpoles. It basks on riverside bushes.

KNOB-SCALED LIZARD
Xenosaurus grandis
A flat-bodied lizard found on the floor of Mexican rain forests, it feeds on flying insects at night. It remains hidden during the day.

MONITOR LIZARDS

Widely distributed throughout tropical Africa, Asia, and Australia, the Varanidae are the largest of all living lizards. They have elongated bodies and strong legs, and many produce toxic saliva. Their choice of prey depends on their size.

HEATH MONITOR
Varanus rosenbergi
Found around the coasts of southern Australia, this monitor has a varied diet. It is a strong digger and often forages underground for food.

ASIAN WATER MONITOR
Varanus salvator
This monitor is found in rain forests and wet habitats of southern Asia. Its large size allows it to tackle a variety of prey.

SAVANNA MONITOR
Varanus exanthematicus
Found in the savanna of sub-Saharan Africa, this species forages for invertebrates and other animals small enough to swallow.

NIGHT LIZARDS

The 30 or so Xantusiidae species are restricted to North and Central America. These secretive, viviparous lizards are crepuscular (active at twilight) or diurnal rather than nocturnal. They have large headshields and rectangular belly scales.

YELLOW-SPOTTED NIGHT LIZARD
Lepidophyma flavimaculatum
Found among rotting logs in the wet forests of Central America, this species feeds on insects.

ANGUID LIZARDS

The Anguidae include both legless forms and species with normal limbs. Most lizards are surface dwellers and occur in a range of habitats in the Old and New Worlds. Though often insectivorous, these lizards will feed on a range of prey. They lay eggs.

SLOW WORM
Anguis fragilis
A legless lizard found in well-vegetated habitats across Europe, this species favors compost piles, where it preys on invertebrates.

EUROPEAN GLASS LIZARD
Pseudopus apodus
Found in the dry habitats of southern Europe, this legless lizard hunts during the day for large insects and small lizards.

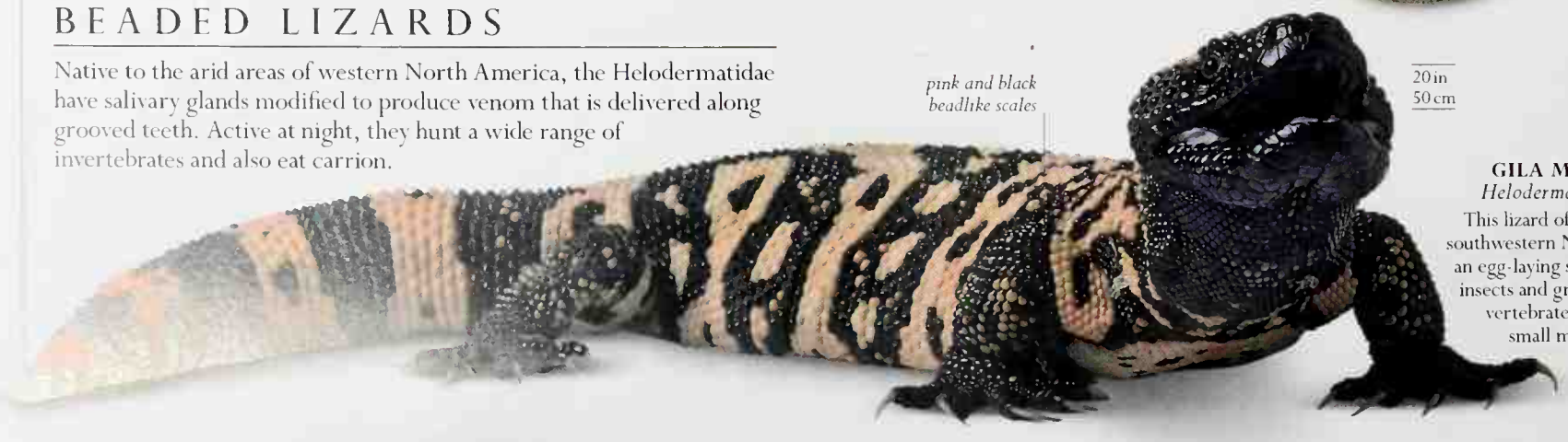
AMERICAN LEGLESS LIZARDS

Found only in the deserts of western North America, the Anniellidae comprises two species. Both have long, cylindrical bodies and small heads, and burrow to hunt invertebrates. They give birth to one or two live young.

CALIFORNIA LEGLESS LIZARD
Anniella pulchra
An insectivorous, wormlike lizard, this species burrows in sand or loose soil. It can detach its tail to trick predators.

BEADED LIZARDS

Native to the arid areas of western North America, the Helodermatidae have salivary glands modified to produce venom that is delivered along grooved teeth. Active at night, they hunt a wide range of invertebrates and also eat carrion.



GILA MONSTER
Heloderma suspectum
This lizard of the deserts of southwestern North America is an egg-laying species. It hunts insects and ground-dwelling vertebrates, including small mammals.

PERENTIE
Varanus giganteus
The largest lizard in Australia, this shy species inhabits arid regions. It has a varied diet and mildly venomous saliva.

spotted pattern of scales

8½ ft
2.5 m

6½ ft
2 m

NILE MONITOR
Varanus niloticus
The second largest reptile in Africa, this monitor preys on various vertebrates and mollusks, and also scavenges on carrion.

strong claws for digging out prey

4½ ft
1.4 m

YELLOW-SPOTTED MONITOR
Varanus panoptes
This species from Australia and southern New Guinea is rarely found far from a permanent source of water. It preys on other reptiles.

4½ ft
1.4 m

GOULD'S GOANNA
Varanus gouldii
This monitor actively forages for any animal smaller than itself. It is found in open woodlands and grasslands throughout Australia.

10 ft
3.1 m

skin folds on neck

well developed, strong limbs

grayish brown scaly skin

KOMODO DRAGON
Varanus komodoensis
The world's largest lizard, this species is restricted to a few Indonesian islands. It is a formidable predator of large mammals.

AMPHISBAENIANS

They may resemble legless lizards, but the burrowing reptiles in the suborder Amphisbaenia are quite distinct in their anatomy and behavior.

The amphisbaenians, or worm-lizards, are reptiles wholly adapted to a subterranean lifestyle, spending almost their entire lives underground. Most species have lost all trace of their limbs and have elongated bodies with smooth scales. They hunt for soil invertebrates by means of scent and sound, killing them in their crushing jaws. Burrowing involves the worm-lizard propelling itself forward by contracting and extending its body while the specially adapted head pushes through the soil. The eyes are protected by tough, translucent skin. Fertilization is internal, with some species laying eggs, others bearing live young. They are found in Florida, South America, Africa, the Middle East, and southern Europe.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDER	SQUAMATA
FAMILIES (AMPHISBAENIANS)	4
SPECIES	165

WORM-LIZARDS

All the Amphisbaenidae are burrowing reptiles with specially adapted heads for digging. They are found in sub-Saharan Africa and South America. They are formidable predators of soil invertebrates, hunting by scent and sound.

heavily ossified skull

black and white markings

18 in
45 cm

SPECKLED WORM-LIZARD
Amphisbaena fuliginosa
This worm-lizard hunts invertebrates while burrowing through leaf litter in the rain forests of South America. It surfaces during heavy rains.

EUROPEAN WORM-LIZARD
Blanus cinereus
Rarely seen above ground, this burrowing reptile from Spain and Morocco forages in leaf litter for invertebrates, particularly ants.

12 in
30 cm

6¾ in
17 cm

LANG'S ROUND-HEADED WORM-LIZARD
Chirindia langi
Found in southern Africa, this species burrows through sandy soil to forage for termites. If caught, it can shed its tail in a bid to escape.

SNAKES

Snakes are predators with elongated bodies and skins of overlapping scales. In a number of species modified teeth, or fangs, are used to deliver venom.

Although most numerous in tropical regions, snakes have adapted to live at colder latitudes and at altitude and are found on all continents except Antarctica. They are usually terrestrial with many living in trees, but some species burrow, some are semiaquatic, and others live entirely in the sea. The smallest are tiny, threadlike creatures, but the largest can reach 33 ft (10 m) in length. Most are between 1 and 6½ ft (30 cm–2 m).

A UNIQUE ARRAY OF SENSES

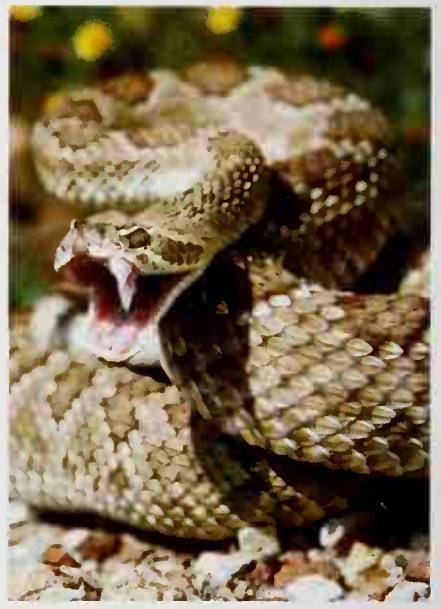
Some snakes have external vestiges of hind limbs, but they move by muscular contractions creating traction between the scales on their undersides and the surface beneath. A large number of flexibly linked vertebrae allows bending and coiling in any direction. The scaly skin is regularly shed to allow growth. Many snakes rely on just one elongated lung for breathing, while the gut is a simple tube with a large, muscular stomach. Instead of eyelids that can be opened and closed, each eye is covered by a clear, protective scale. Eyesight can be good, but varies according to lifestyle. Lacking external ears, snakes detect sounds as vibrations from the ground as well as in the air. Their key sense is smell, not through the nostrils, but from airborne chemicals collected by the forked tongue. Some species can also detect the body heat of mammals and birds.

KILLING TO LIVE

All snakes are carnivorous. Their sharp teeth curve backward to grasp and hold prey. Whether they eat their victim alive or kill it by injection of venom or by constriction, they consume their prey whole. Their uniquely elastic jaws allow them to swallow animals much larger than a snake's own head. Snakes defend themselves by camouflage, warning coloration, or mimicry. When threatened, they may strike out and bite.

Species in cold places tend to bear live offspring, whereas those in warmer climates lay eggs. Fertilization is internal. The male deposits sperm by means of one of his paired sexual organs, known as hemipenes.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDER	SQUAMATA
FAMILIES (SNAKES)	18
SPECIES	Over 2,700



If threatened, the Mojave rattlesnake uses its characteristic rattle, bares its fangs, and coils up, ready to strike at the aggressor.

BURROWING VIPERS

Members of this family of snakes from Africa and southwest Asia are all venomous. Despite their common name they are not closely related to the Viperidae—the position of the fangs differs from that of the true vipers. The burrowing vipers, the Atractaspididae, hunt small mammals and reptiles underground. Their relatively small size, smooth scales, and cylindrical bodies are all adaptations for their burrowing way of life. Most species in the family lay eggs.

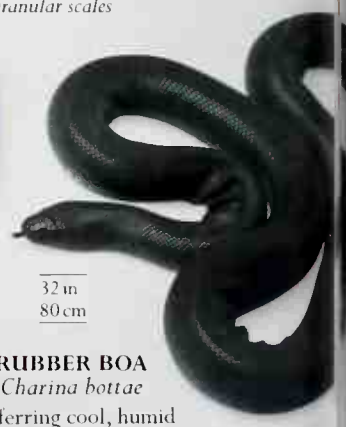
MOLE VIPER
Atractaspis fallax
This poisonous snake from East Africa has large erect fangs. It hunts other burrowing vertebrates underground.

BOAS

The majority of Boidae are found in Central and South America, but a few species of boas are also present in Madagascar and New Guinea. These snakes are found from trees to marshes, where they prey on vertebrates, killing them by constriction. This family includes the anaconda, the largest living snake, and other species of varying sizes. Most give birth to live young.

BOA CONSTRICTOR
Boa constrictor imperator
This relatively small subspecies lives in a variety of habitats in Central America. It is a nocturnal hunter of small mammals.

DUMERIL'S BOA
Acrantophis dumerili
Found in the humid forests of Madagascar, this snake becomes torpid when sheltering in burrows during the dry, cool months.



RUBBER BOA
Charina bottae
Preferring cool, humid conditions, this burrowing species is found at high altitudes and as far north as British Columbia.

EAST AFRICAN SAND BOA
Gongylophis colubrinus

This African snake, with a stout body and short tail, waits in a burrow with only its head exposed to catch unsuspecting prey.

35 in
90 cm

small, smooth scales assist in burrowing

5½ ft
1.1 m

head with small eyes

headlike tail used in defense

mottled brown coloration for camouflage

long, muscular body

8¼ ft
2.5 m

CALABAR GROUND BOA
Calabaria reinhardtii

Native to West Africa, the Calabar ground boa hunts in burrows for small mammals. It is the only egg-laying boa.

RAINBOW BOA
Epicrates cenchria

Microscopic ridges on the scales of this South American snake refract light to give it an iridescent sheen. It hunts for mammals in forests.

6½ ft
2 m

smooth, glossy scales

3¾ ft
1 m

COOK'S TREE BOA
Corallus cookii

Endemic to St. Vincent Island in the Caribbean, this rare snake hunts in trees for birds and mammals under the cover of darkness.

5 ft
1.5 m

NEW GUINEA GROUND BOA
Candoia aspera

A sharply angled snout helps to identify this New Guinea snake. It is a slow-moving terrestrial hunter of small vertebrates.

33 ft
10 m

ROSY BOA
Lichanura trivirgata

This is a slow-moving snake from the deserts of the western US. It ambushes mammals and kills them by constriction.

3¼ ft
1 m

dull yellow color with prominent black spots

thick, muscular body used to constrict prey

GREEN ANACONDA
Eunectes murinus

This aquatic South American species is the largest of the New World snakes. It hides in water and kills its prey by constriction.

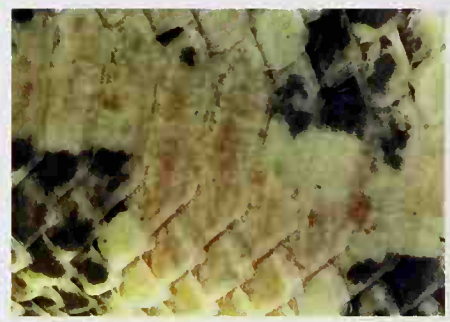
COMMON BOA
Boa constrictor

The common boa is a large terrestrial snake from the tropics of Central and South America. Although they are often found in woodland and scrub, boas easily adapt to a variety of habitats. Lying motionless on the ground, the snake ambushes its mammalian prey—grasping its victim with its jaws, it coils around, suffocating and killing by slow constriction before swallowing the body whole. The left and right sides of the boa's lower jaw separate in front, and can open wide to take astonishingly large prey. Usually a solitary species, males will actively seek out a partner at breeding times, attracted by the scent emitted by the female. Larger than males, female boas give birth to 30–50 live offspring, each measuring about 12 in (30 cm) in length. This species is regularly seen in captivity but its propensity to bite makes it an unpredictable pet.

SIZE Up to 8¼ ft (2.5 m)
HABITAT Open woodland and scrubland
DISTRIBUTION Central and South America
DIET Mammals, birds, reptiles

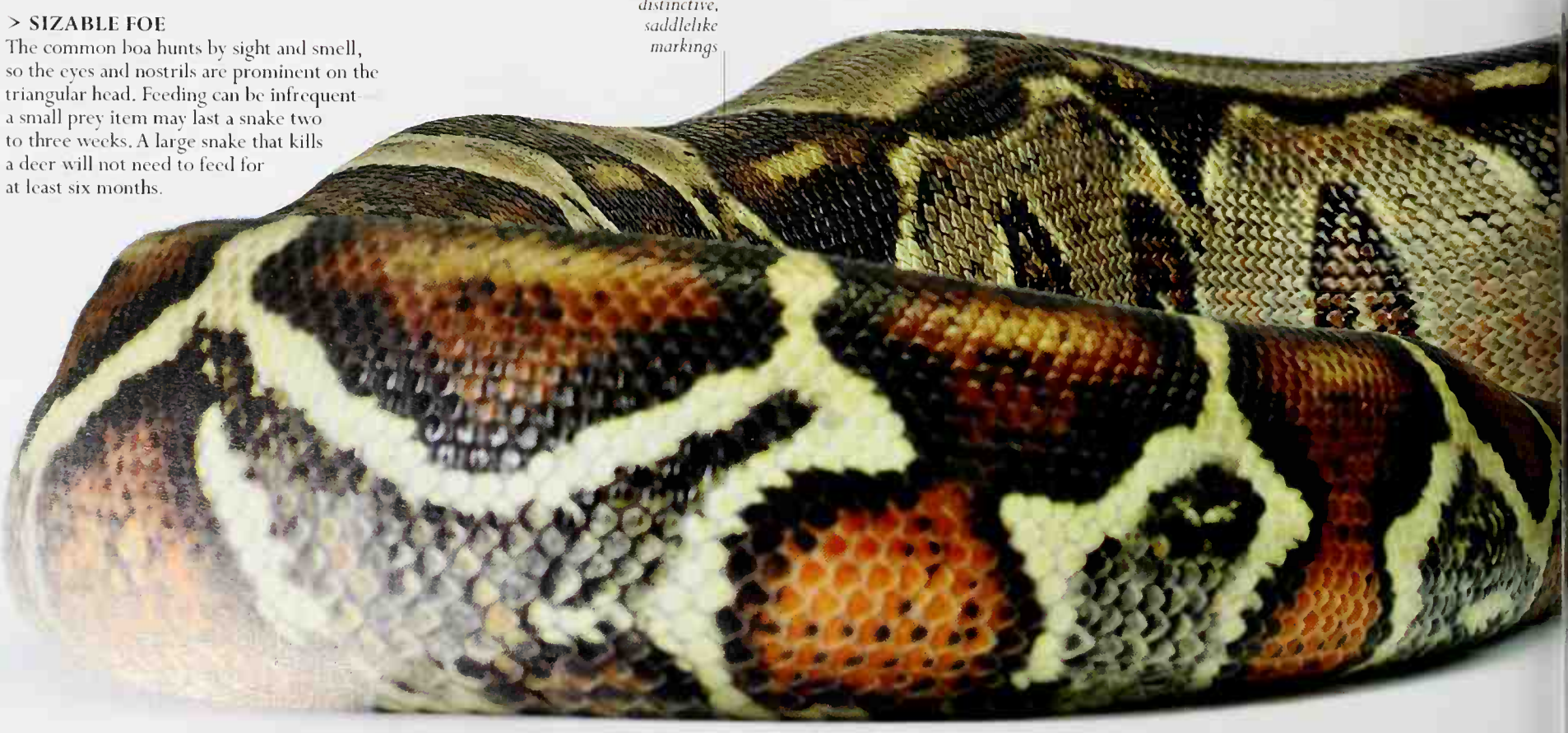
^ COLOR VARIANTS
There are numerous subspecies of common boa, which are defined on the basis of size and color patterns. Color also varies considerably between localities.

> CAMOUFLAGE
Pigmentation of some scales forms patches of color that disrupt the outline of the snake. This helps camouflage it when hunting prey or evading predators.



^ BELLY SCALES
The robust belly scales grip most surfaces, allowing the common boa to pull itself along and climb trees. It periodically sheds its skin.

> SIZABLE FOE
The common boa hunts by sight and smell, so the eyes and nostrils are prominent on the triangular head. Feeding can be infrequent—a small prey item may last a snake two to three weeks. A large snake that kills a deer will not need to feed for at least six months.



even when closed, the mouth has a hole that allows the tongue to be extended

forked tongue

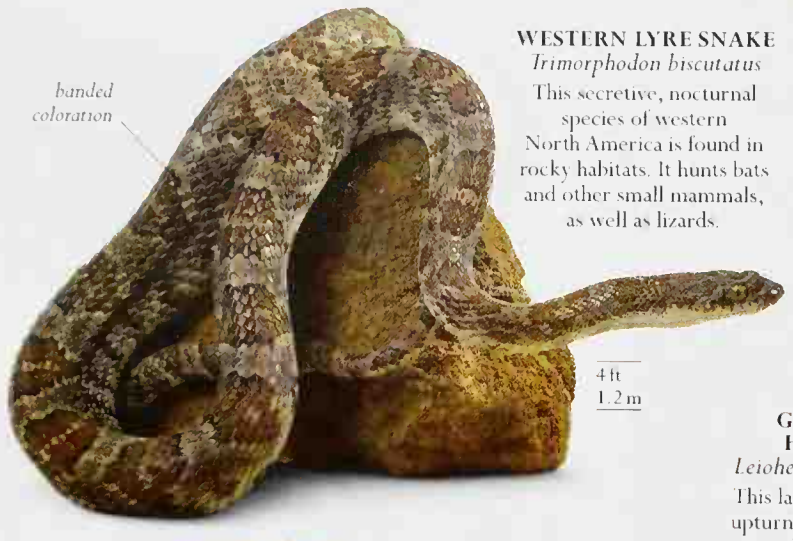
< EYE
The boa has keen eyesight, and the pupil narrows to a slit in bright light. It has no eyelids. Around the eyes, the head is covered with numerous small scales, which are made of keratin.

REMNANT LIMBS ^ >
All snakes lack limbs, but more primitive species like the common boa still possess the remnants of a pelvis, as well as tiny, spurlike hind limbs on each side of the anal vent—these would once have been legs.

TONGUE FLICKING ^
The forked tongue is an important sense organ. Snakes flick their tongues, collecting chemicals from the air; these are then analyzed by the Jacobson's organ in the roof of the mouth.

COLUBRIDS

With over 1,600 species worldwide, colubrids form the largest family of snakes. The members of the family Colubridae inhabit a wide range of habitats, from deserts to wetlands. They have a varied diet. Many species lay eggs.

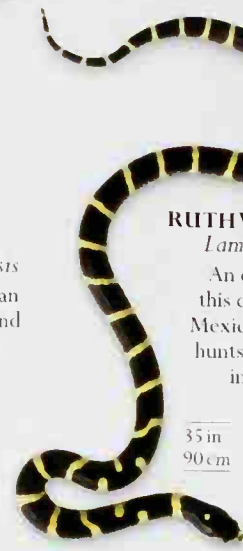


WESTERN LYRE SNAKE
Trimorphodon biscutatus
This secretive, nocturnal species of western North America is found in rocky habitats. It hunts bats and other small mammals, as well as lizards.

GIANT MALAGASY HOGNOSE SNAKE
Leioheterodon madagascariensis
This large, diurnal snake, with an upturned snout, hunts lizards and amphibians in grasslands and forests in Madagascar.

COMMON GARTER SNAKE
Thamnophis sirtalis
This North American species is active in the daytime, hunting vertebrates in a range of habitats. In Manitoba, after hibernation it congregates in large numbers to mate.

GRAY EARTHSNAKE
Geophis brachycephalus
This small, Central American snake is terrestrial and nocturnal. It feeds mainly on earthworms and soft insect larvae.



RUTHVEN'S KINGSNAKE
Lampropeltis ruthveni
An egg-laying species, this colubrid is from the Mexican plateau, where it hunts rodents and lizards in dry woodland.

LONG-NOSED SNAKE
Rhinocheilus lecontei
Characterized by a pointed snout, this shy, nocturnal, burrowing species is from dry grasslands of North America, where it hunts lizards.

MOLE SNAKE
Pseudaspis cana
This harmless species lives in underground burrows, where it feeds on moles and other small mammals after constricting them. It is found in southern Africa.

CALIFORNIA MOUNTAIN KINGSNAKE
Lampropeltis zonata
This secretive snake prefers high-altitude wooded habitats. It is typically nocturnal, but is diurnal when nights are cold.

AFRICAN EGG-EATING SNAKE
Dasypeltis scabra
This African snake has a highly specialized diet of eggs on which it feasts during the bird-nesting season. It then fasts for the rest of the year.

EASTERN PINE SNAKE
Pituophis melanoleucus
When threatened, this large, powerful snake of woodlands in North America ejects foul-smelling waste from its rear opening (cloaca).

3½ ft
1 m

long, slender body

GREEN HIGHLAND RACER
Drymobius chloroticus

This fast, agile snake is from the rain forests of Central America. It is usually found near water, where it feeds on frogs.

WESTERN INDIGO SNAKE
Drymarchon corais

This is one of the longest snakes in North America. It often shares a burrow with the gopher tortoise.

4½ ft
1.4 m

9½ ft
3 m

4 ft
1.2 m

BANDED FLYING SNAKE
Chrysopelea pelias

Despite its name, this southern Asian snake does not actively fly. Instead, it glides down from high branches by making its underside concave.

NORTHERN WATER SNAKE
Nerodia sipedon

This aquatic, viviparous species from eastern North America is active throughout the day and the night. It feeds on amphibians and fishes.

26 in
65 cm

short snout

FALSE CORAL SNAKE
Erythrolamprus mimus

The bright coloration of the harmless false coral snake from South America is similar to that of highly poisonous coral snakes.

striking red, white, and black bands

6 ft
1.8 m

MOELLENDORFF'S RAT SNAKE
Orthriophis moellendorffi

This species is from dry limestone regions of China and Vietnam. It has an elongated snout and a relatively long tail.

7 ft
2.1 m

MUD SNAKE
Farancia abacura

This North American snake preys on aquatic salamanders, grasping them with strongly curved teeth. Females remain coiled around their eggs until they hatch.

3½ ft
99 cm

NORTHERN CAT-EYED SNAKE
Leptodeira septentrionalis

This nocturnal, arboreal species from Central America has large eyes to help it hunt for vertebrates and eggs of tree frogs.

4½ ft
1.3 m

BROWN BLUNT-HEADED VINE SNAKE
Imantodes cenchoa

The large eyes of this slender snake help it hunt lizards in the dark. It is found in tropical American rain forests.

16 in
40 cm

REDBACK COFFEE SNAKE
Nimia sebae

This harmless snake from Central America has an ability to extend its neck as a form of intimidation.

3½ ft
1 m

BROWN TREESNAKE
Boiga irregularis

Originally from Australia and New Guinea, this snake was accidentally introduced on the island of Guam in the western Pacific, where it has decimated the native fauna.

9½ ft
3 m

FALSE WATER COBRA
Hydrodynastes gigas

Native to South American rain forests, this is a semiaquatic snake. Like cobras, it can flatten its neck to appear more intimidating.

6½ ft
2 m

GREEN VINE SNAKE
Oxybelis fulgidus

Long and delicate, this arboreal snake from Central and South American rain forests holds its prey in the air until its venom immobilizes the victims.

3½ ft
1.1 m

CALICO SNAKE
Oxyrhopus petola

This species feeds on lizards and other small vertebrates. It is a terrestrial and diurnal inhabitant of South American rain forests.

characteristic yellow collar

4 ft
1.2 m

olive-gray body color

GRASS SNAKE
Natrix natrix

Widely distributed throughout Europe, this species often feigns death when threatened. At home in water, it regularly feeds on amphibians.

»

» COLUBRIDS

4½ ft
1.4 m

COMMON TRINKET SNAKE
Coelognathus helena
This Indian species enlarges its neck and rises up to intimidate its enemies. It hunts mammals, usually at night.

5¼ ft
1.6 m

ROUGH GREENSNAKE
Opheodrys aestivus
Native to woodlands in southeastern North America, this arboreal snake is a diurnal predator of insects. It is oviparous.

7¾ ft
2.4 m

long, slender body

RED-TAILED GREEN RATSNAKE
Gonyosoma oxycephalum
This fast-moving snake hunts for birds and mammals in trees. It is found in the rain forests of Southeast Asia.

5¼ ft
1.6 m

23½ in
60 cm

SMOOTH SNAKE
Coronella austriaca
This secretive European snake, found in meadows, kills its prey by constriction. Females produce eggs that hatch within their bodies.

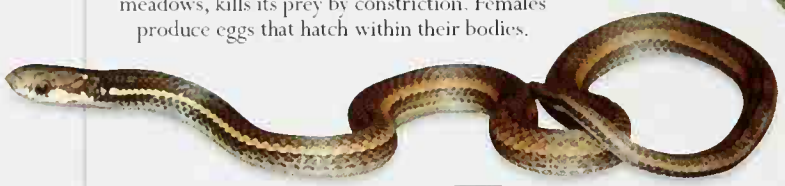
3¼ ft
1 m

BALKAN RACER
Hierophis gemonensis
Restricted to the Balkans, this snake is found in dry scrubland and olive groves. It hunts during the day, preying on lizards.

4½ ft
1.4 m

DAHL'S WHIPSNAKE
Platyceps najadum
From the Mediterranean region, this snake is found in dry, stony hahitats. It hunts small lizards and grasshoppers during the day.

SOUTHERN WATER SNAKE
Nerodia fasciata
Living in wetlands, this colubrid preys on amphibians and fishes. It is found in the southern US.



8 in
20 cm

BROWN-HEADED CENTIPEDE SNAKE
Tantilla melanocephala ruficeps
This burrowing snake is found in the tropical forests of Central America. It is a mainly diurnal insect eater.

head with prominent eyes
brown markings on muscular body
pale underside
6 ft
1.8 m

DIADEM SNAKE
Spalaerosophis diadema cliffordi
Native to deserts in North Africa, this subspecies is diurnal during cooler months, but turns nocturnal during summer months.

6 ft
1.8 m

RED CORN SNAKE
Pantherophis guttatus
This snake is common in southeastern North America, hut is rarely seen. It hunts small mammals in woodland.

6½ ft
2 m

YELLOW RATSNAKE
Spilotes pullatus
A predator of small vertebrates, this large snake is rarely found far from water. It is widely distributed in South and Central America.

32 in
80 cm

WESTERN HOGNOSED SNAKE
Heterodon nasicus
This snake of the North American prairies uses its specialized, enlarged teeth to puncture the lungs of toads, making them easier to swallow.

6½ ft
2 m

MONTPELLIER SNAKE
Malpolon monspessulanus
Inhabiting dry scrub and rocky hillsides around the Mediterranean, this long, slender snake hunts small vertebrates during the day.

ASIAN PIPE SNAKES

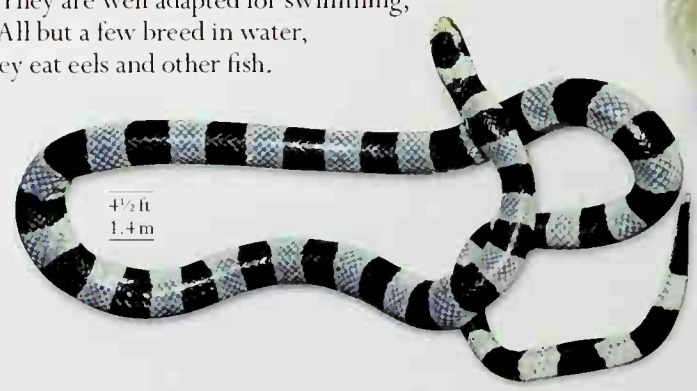
Found in Sri Lanka and Southeast Asia, these small, burrowing snakes of the Cylindrophiidae have cylindrical bodies and smooth, shiny scales. They live in wet habitats, sheltering in tunnels, but emerge at night to hunt other snakes and eels. They give birth to live young.

26 in
65 cm

CEYLONESE PIPESNAKE
Cylindrophis maculatus
Endemic to Sri Lanka, this harmless burrowing snake eats [illegible]. It uses its flattened tail to mimic the movements of the venomous cobra.

SEA SNAKES

These highly venomous snakes from the tropical coastal waters of the Indian and Pacific oceans belong to the subfamily Hydrophiinae, part of the larger Elapidae. They are well adapted for swimming, with a paddlelike tail. All but a few breed in water, bearing live young. They eat eels and other fish.



4½ ft
1.4 m

YELLOW-LIPPED SEAKRAIT
Laticauda colubrina
This snake hunts fish at night in tropical Indo-Pacific seas. It can move on land as well.

COBRAS AND RELATIVES

Widely distributed in the tropics, the venomous snakes of the Elapidae have short, permanently erect fangs at the front of the mouth. Varied in body forms, they occupy a wide variety of habitats. Some species lay eggs, while others bear live young.

4 ft
1.2 m

YELLOW-FACED WHIP SNAKE
Demansia psammophis
Widely distributed across Australia, this slender snake is an active diurnal hunter of lizards. It prefers dry, open habitats.

small, slender head

32 in
80 cm

CENTRAL AMERICAN CORAL SNAKE
Micrurus nigrocinctus
This venomous snake of Central America forages in leaf litter of tropical forests. Its bright coloration serves as a warning to potential aggressors.

30 in
75 cm

EASTERN SHIELD-NOSE SNAKE
Aspidelaps scutatus fulafulus
This nocturnal predator of small lizards and mammals is found in southern African savanna. It burrows in sandy soil.

26 in
65 cm

ROSEN'S SNAKE
Suta fasciata
Found in arid areas of Western Australia, this venomous snake hunts for lizards.

spread hood acts as warning

6 ft
2 m

MONOCLED COBRA
Naja kaouthia
Common in Southeast Asia, this large snake hunts rats and other snakes in woodland and paddy fields, often close to human habitation.

28 in
70 cm

DESERT DEATH ADDER
Acanthophis pyrrhus
This predator of the western deserts of Australia lures its prey of small lizards and mammals by wiggling its tail. It then ambushes them.

20 in
50 cm

RINGED BROWN SNAKE
Pseudonaja modesta
Found in dry, rocky areas in Australia, this venomous snake feeds on small skinks. Its survival is threatened by the loss of its habitat.

14 in
35 cm

SOUTHERN DESERT BANDED SNAKE
Simoselaps bertholdi
Widespread in Western Australia, this small snake burrows in search of its lizard prey. The banding may confuse predators.

7½ ft
2.4 m

EGYPTIAN COBRA
Naja haje
This large cobra hunts small vertebrates in the deserts of North and Central Africa. When threatened, it spreads its hood and raises its head.

olive coloration on long, thin body

16 ft
5 m

KING COBRA
Ophiophagus hannah
A forest species of tropical Asia, the massive king cobra primarily preys on other snakes. Unusually for snakes, its nest of eggs is defended by both sexes.

smooth scales on brown body

30 in
75 cm

RED SPITTING COBRA
Naja pallida
This African species not only raises its hood when threatened, but also sprays streams of venom into the face of its aggressor.

PYTHONS

Members of the family Pythonidae can be found across Africa, Asia, and Australia. Pythons detect warm-blooded prey with their facial pits. They use their mouth to grasp prey but kill by constriction. Some species coil around their eggs to help incubate them using the heat generated by their shivering.

5 ft
1.5 m

GREEN TREEPYTHON
Morelia viridis
Found in the tropical forests of Australasia, this arboreal snake spends its time looped over a branch, ready to ambush lizards and small mammals.

bright green color aids in camouflage

BLOOD PYTHON
Python curtus
This relatively short python of Southeast Asian rain forests coils around its clutch of eggs to incubate and protect them.

6 ft
1.8 m

9¾ ft
3 m

BLACK-HEADED PYTHON
Aspidites melanocephalus
Endemic to Australia, this species is found in a variety of habitats. It preys upon other snakes and reptiles.

BURMESE PYTHON
Python molurus
Rare in its native homeland, this Asian snake is becoming superabundant in the Florida Everglades. Its broad diet of birds, mammals, and reptiles is a threat to many local animals.

23 ft
7 m

BLINDSNAKES

The Typhlopidae have eyes covered with scales, rendering them effectively blind. Found in leaf litter of tropical forests, these small, burrowing snakes mainly eat soil invertebrates and have teeth only on their upper jaw. Most of them lay eggs.

14 in
35 cm

30 in
75 cm

BLACKISH BLINDSNAKE
Austrotyphlops nigrescens
Tough scales allow this burrowing snake from eastern Australia to resist attack from ants while eating their eggs and larvae.

EURASIAN BLINDSNAKE
Typhlops vermicularis
This wormlike blind snake from Europe inhabits dry, open areas. It burrows to feed on invertebrates, mainly ant larvae.

THREAD SNAKES

These small, slender snakes are rarely seen because of their habit of burrowing to hunt invertebrates. Belonging to the Leptotyphlopidae, they are found in the tropics of the Americas, Africa, and southwest Asia.

12 in
30 cm

SENEGAL BLINDSNAKE
Myriopholis rouxestevae
This snake inhabits the soil of tropical forests in western Africa. First studied in 2004, it is believed to eat invertebrates.

VIPERS

The Viperidae are characterized by thick bodies, keeled scales, and a triangular head. Long, tubular, hinged fangs at the front of the mouth efficiently inject venom into their vertebrate prey. Pit vipers have sensory pits between their eyes and nostrils that detect heat. Most vipers bear live young.

5 ft
1.5 m

FER-DE-LANCE
Bothrops atrox
Found in the forests of tropical America, this venomous snake is characterized by a sharply pointed head. It hunts birds and mammals by night.

34 in
85 cm

23½ in
60 cm

DESERT HORNED VIPER
Cerastes cerastes
Occurring in the deserts of North Africa and the Sinai Peninsula, this snake lies buried in sand to ambush small mammals and lizards.

HOGNOSE PIT VIPER
Porthidium nasutum
This diurnal hunter of Central America prefers humid, open forests. Pit vipers have heat-detecting sensory pits between their eyes and nostrils and bear live young.

bleached markings

4–5 ft
1.3 m

SPOTTED PYTHON
Antaresia maculosa
This python is found on the rocky hillsides of northern Australia. It feeds on bats by catching them at the entrance of their roosting caves.

SUNBEAM SNAKES

Characterized by iridescent scales, the Xenopeltidae include only two species, both restricted to Southeast Asia. They live in burrows in forest habitats and hunt amphibians, other reptiles, and small mammals. They reproduce by laying eggs.

4–5 ft
1.3 m

SUNBEAM SNAKE
Xenopeltis unicolor
A flat head helps this snake burrow into decaying vegetation. It emerges at dusk to feed on amphibians and small mammals.

33 ft
10 m

arrowhead pattern

powerful, muscular body useful for constricting prey

RETICULATED PYTHON
Python reticulatus
One of the longest snakes in the world, this species inhabits Asian rain forests. It kills large mammals by constriction.

4–5 ft
1.3 m

COPPERHEAD
Agkistrodon contortrix
Banded markings help this snake hide in leaf litter in rocky woodland. It is found in eastern North America.

23½ in
60 cm

ASP VIPER
Vipera aspis
This European viper prefers warm, dry habitats, where it feeds on small mammals. It bears up to 20 live young.

35 in
90 cm

COMMON ADDER
Vipera berus
This diurnal species hunts small mammals and lizards. It is widely distributed across a variety of habitats in Eurasia.

4 ft
1.2 m

short, dark-edged blotches

PRAIRIE RATTLESNAKE
Crotalus viridis
This snake from the midwestern US hunts mammals around dawn and dusk. It hides in crevices by day.

6½ ft
2 m

GABOON VIPER
Bitis gabonica
Occurring in tropical rain forests in Africa, this large, heavily built snake preys on mammals by ambushing them.

7 ft
2.1 m

WESTERN DIAMOND-BACKED RATTLESNAKE
Crotalus atrox
A nocturnal hunter of mammals, this large snake is widespread in arid areas of western North America.

large head

6 ft
1.8 m

PUFF ADDER
Bitis arietans
Most active at night, this venomous snake usually lies still to ambush its vertebrate prey. It is found in rocky grassland in Africa.

3–6 ft
1 m

MALAYAN PIT VIPER
Calloselasma rhodostoma
Occurring in Southeast Asia, this species forages by night in open areas adjacent to forests for rodents and lizards.

CROCODILES AND ALLIGATORS

Crocodilians are large, carnivorous, aquatic reptiles. Their armored skin and powerful jaws make them formidable predators, yet they are social animals and caring parents.

All crocodilians—crocodiles, alligators, and gharials—have a similar body plan: an elongated snout armed with numerous, sharp, unspecialized teeth, a streamlined body, a long, muscular tail, and skin armored with bony plates. The saltwater crocodile is the largest living reptile.

SWIMMING AND FEEDING

Crocodilians are found in tropical regions worldwide, inhabiting a variety of freshwater and marine habitats. The eyes, ears, and nostrils are on top of the head, which enables the animal to be almost completely submerged while hunting. The powerful tail is used for swimming and strong legs allow crocodilians to move easily on land with the body raised well above the ground.

Although generalized carnivores, feeding on fish, reptiles, birds, and mammals, crocodilians exhibit sophisticated feeding behaviors to locate and ambush specific prey, such as migrating mammals and fish. Small prey is swallowed whole but large prey is first drowned before the crocodilian rolls over while grasping the carcass to twist off pieces of meat. Digestion is aided by stones in the stomach and highly acidic gastric secretions.

SOCIAL BEHAVIOR AND BREEDING

Behaviorally, crocodilians have more in common with birds, their closest living relatives, than with other reptiles. Adults form loose groupings—particularly at good feeding sites—and use a wide range of vocalizations and body language to interact with each other.

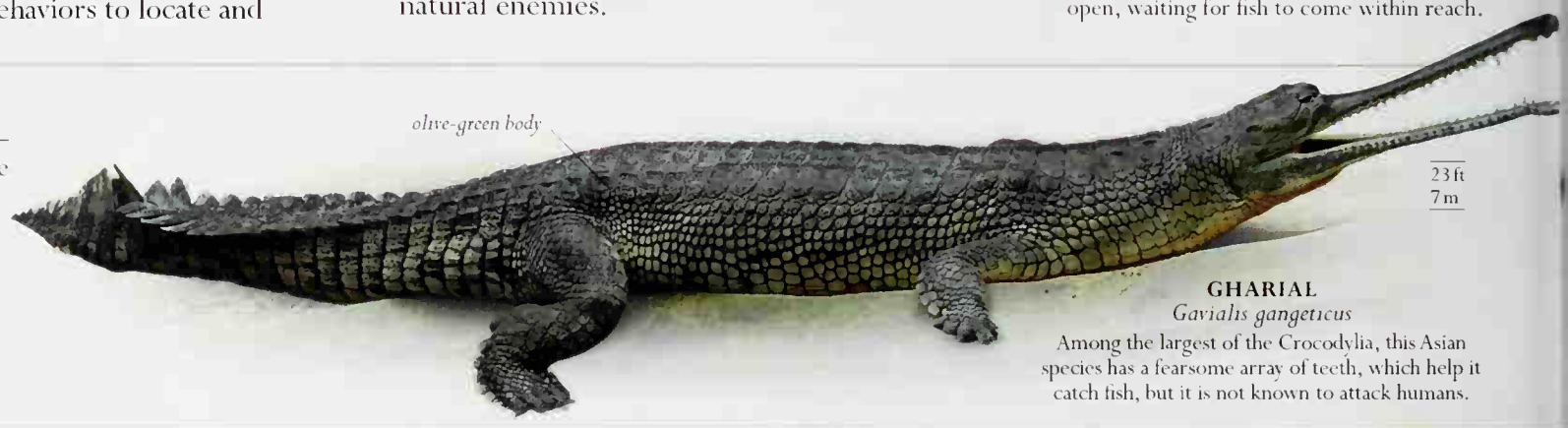
In the breeding season, dominant males control territories and actively court females. Fertilization is internal and clutches of rigid-shelled eggs are laid in a nest constructed and guarded by the female. The sex of individuals is determined by the incubation temperature. Hatchlings call to stimulate the female to excavate the nest and carry them in her mouth to water. Mortality is high in young crocodilians but once they are longer than 3¼ ft (1 m), they have few natural enemies.

PHYLUM	CHORDATA
CLASS	REPTILIA
ORDER	CROCODYLIA
FAMILIES	3
SPECIES	23

Exploiting a fast-flowing stream, these Yacare caimans are lying with their mouths open, waiting for fish to come within reach.

GHARIALS

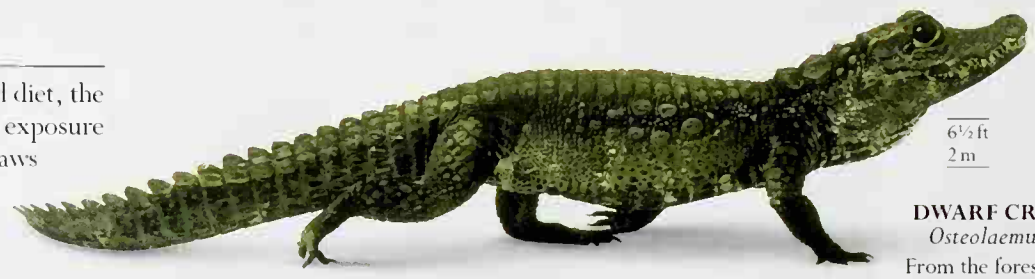
The endangered Gavialidae are restricted to India. The slender snout has rows of numerous sharp teeth that help to catch fish. Males develop a wartlike growth on the tip of the snout.



GHARIAL
Gavialis gangeticus
Among the largest of the Crocodylia, this Asian species has a fearsome array of teeth, which help it catch fish, but it is not known to attack humans.

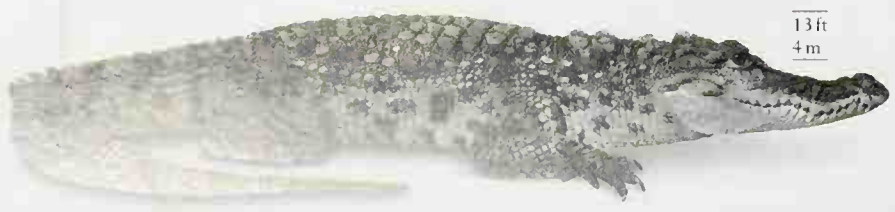
CROCODILES

Relatively unspecialized in lifestyle, habitat, and diet, the Crocodylidae are most easily recognized by the exposure of the fourth tooth of the lower jaw, when the jaws are closed. These tropical reptiles occupy many habitats around rivers and coasts.



DWARF CROCODILE
Osteolaemus tetraspis
From the forests of tropical Africa, this small crocodile has a heavy armor of scales on its neck and back. It is a nocturnal hunter of fishes and frogs.

CUBAN CROCODILE
Crocodylus rhombifer
Endemic to Cuba, this medium-sized crocodile inhabits swamps, and hunts fish and small mammals. It lays its eggs in holes in the ground.

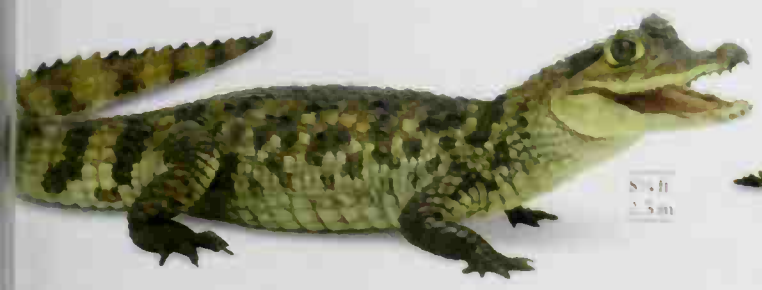


SIAMESE CROCODILE
Crocodylus siamensis
Restricted to Southeast Asia, this large crocodile is critically endangered in the wild. Found in freshwater marshes, it feeds on a variety of prey.

ALLIGATORS AND CAIMANS

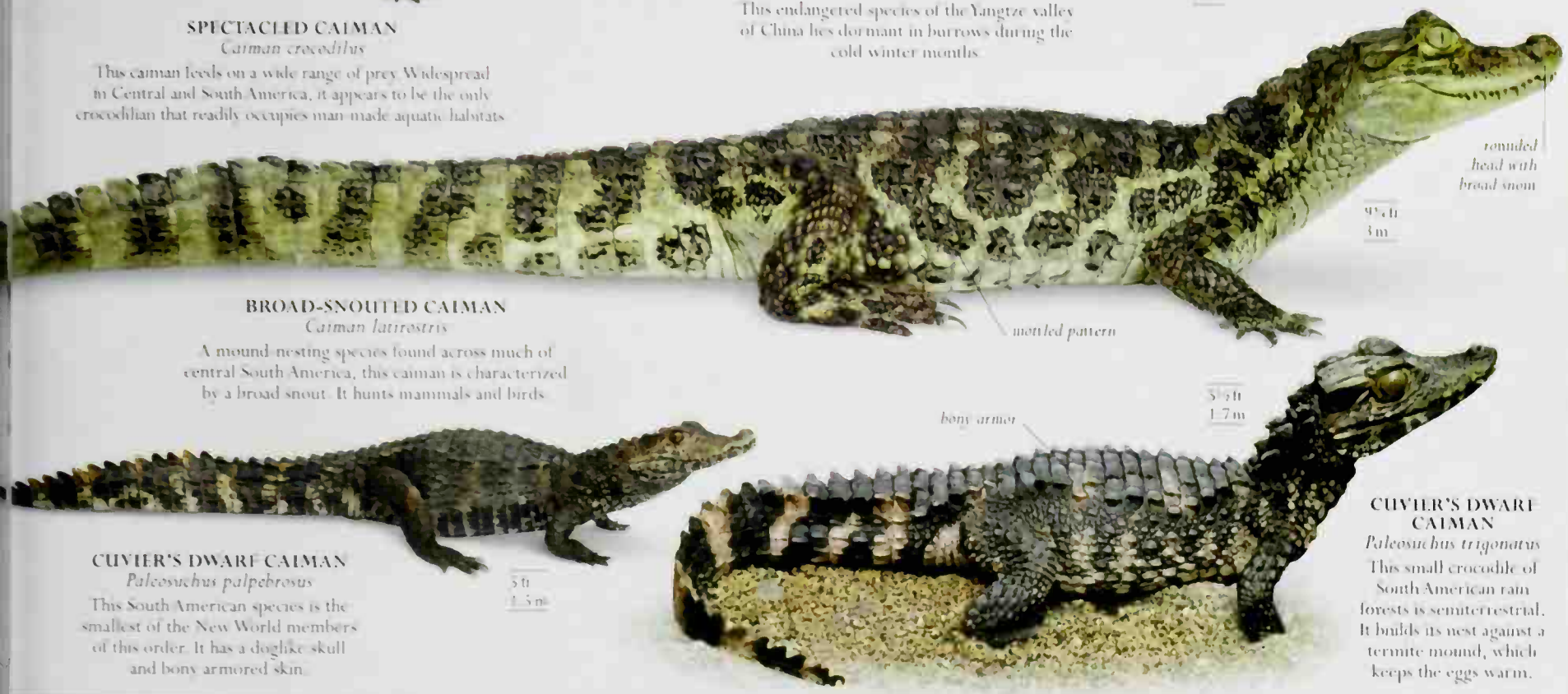
Members of the family Alligatoridae feed on fish, birds, and mammals that share their aquatic habitat. These reptiles are distributed throughout freshwater swamps and rivers of the tropical and subtropical Americas. The only species living outside the Americas is the rare Chinese alligator.

AMERICAN ALLIGATOR
Alligator mississippiensis
Conservation efforts have now made this North American species quite common. It preys on birds, small mammals, and turtles.



SPECTACLED CAIMAN
Caiman crocodilus
This caiman feeds on a wide range of prey. Widespread in Central and South America, it appears to be the only crocodilian that readily occupies man-made aquatic habitats.

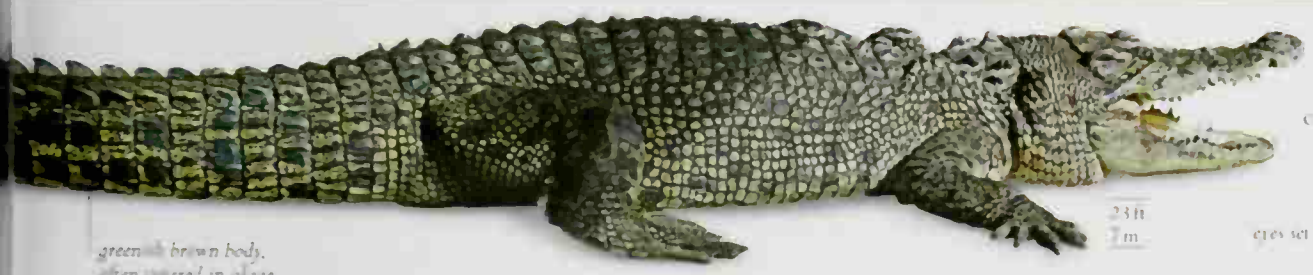
CHINESE ALLIGATOR
Alligator sinensis
This endangered species of the Yangtze valley of China lies dormant in burrows during the cold winter months.



BROAD-SNOUTED CAIMAN
Caiman latirostris
A mound-nesting species found across much of central South America, this caiman is characterized by a broad snout. It hunts mammals and birds.

CUVIER'S DWARF CAIMAN
Paleosuchus palpebrosus
This South American species is the smallest of the New World members of this order. It has a doglike skull and bony armored skin.

CUVIER'S DWARF CAIMAN
Paleosuchus trigonatus
This small crocodile of South American rain forests is semiterrestrial. It builds its nest against a termite mound, which keeps the eggs warm.

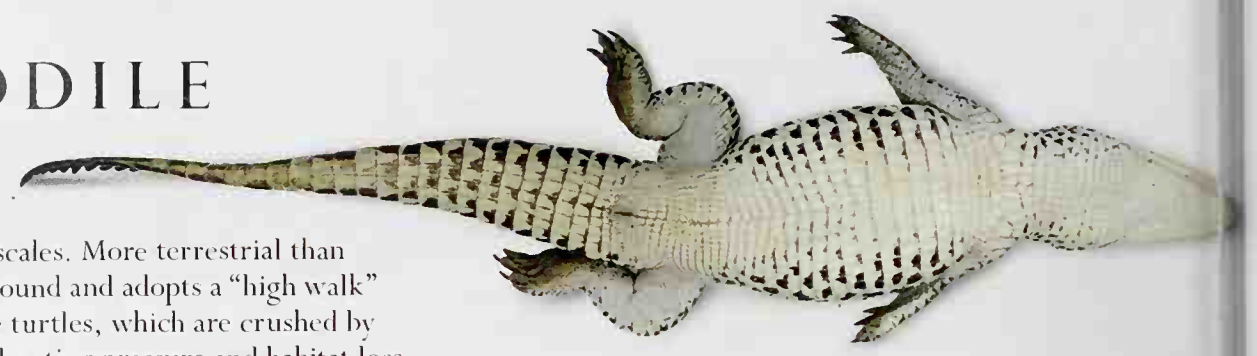


SALTWATER CROCODILE
Crocodylus porosus
This largest of all living reptiles is common in the Indo-Pacific and readily crosses the open ocean. Its diet is wide-ranging and unspecialized.

NILE CROCODILE
Crocodylus niloticus
Widely distributed in Africa, this large crocodile typically lives in freshwater but has been seen around coasts as well. Its diet varies with age, with adults taking larger prey.

CUBAN CROCODILE
Crocodylus rhombifer

This strikingly colored crocodile is native to Cuba. It is medium-sized, robust, and armored with bony scales. More terrestrial than other crocodilian species, it raises its belly off the ground and adopts a "high walk" posture when moving on land. Its preferred prey are turtles, which are crushed by the strong teeth at the rear of its mouth. Because of hunting pressure and habitat loss, the few remaining wild Cuban crocodiles were captured in the 1960s and released into Zapata Swamp, a reserve in the south of the island. Although protected, the population remains small, and hybridization with American crocodiles on the reserve threatens the purity of this species.



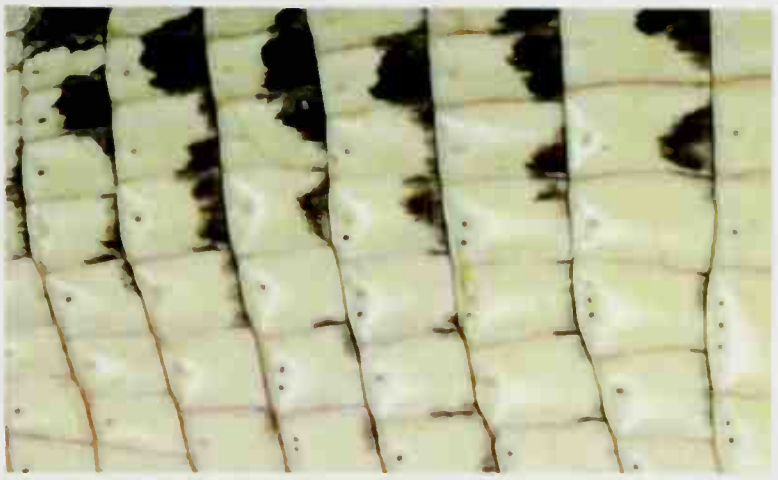
SIZE 9¾–11 ft (3–3.5 m)
HABITAT Freshwater swamps
DISTRIBUTION Cuba
DIET Fish, turtles, small mammals

large scales armored with bony deposits
bony projections at back of the head resemble horns
external ear flap, which is closed while the crocodile is underwater

MUSCULAR LIMBS v >
This crocodile can race over short distances, powered by its strong rear legs. Because they are used for walking rather than swimming, the five toes on each foot are not webbed.

v NOSTRILS
Paired nostrils are located on the nasal disk, an elevated pad of tissue at the end of the snout. Underwater, the nostrils can be closed by valves.

^ TAIL RIDGE
Scales with bony projections increase the depth of the tail, useful when the crocodile is swimming. Rich in blood vessels, they also help absorb heat when basking.



^ FORMIDABLE JAWS
Crocodiles cannot chew their food, but they use their powerful jaws to grasp their prey. Sensitive taste buds on the tongue allow the crocodile to reject unpleasant tasting objects. Evaporation from the mouth cools the body.

< BELLY SCALES
The scales on the crocodile's underside are small and uniform in size and pattern. These scales are prized by the leather trade.

scales along the snout have sensory papillae, which are sensitive to vibrations in the water
nostrils
lower jaw
sharp front teeth
blunt back teeth are more robust than the front teeth

^ STEALTH ATTACK
Sharp eyes and sensitive ears are located on the top of the head, so that prey can be detected while the body is submerged. This enables the crocodile to take its victims by surprise. The long lower jaw can be closed with tremendous force to grasp struggling prey securely.

BIRDS

Birds have busy, active lives. Many are spectacularly beautiful; others sing complex—even musical—songs. They have the intelligence and parental devotion of a mammal combined with characteristics more reminiscent of a reptilian ancestor.

PHYLUM	CHORDATA
CLASS	AVES
ORDERS	29
FAMILIES	196
SPECIES	10,117

Asymmetrical flight feathers, with a narrow outer blade and broader inner blade, give birds better control in the air.

Many chicks are altricial—born in a helpless state. Blind and naked, they require prolonged parental care.

Elaborate nests are built by the male weaver bird to impress prospective mates, testament to the brain power of birds.

DEBATE

ARE BIRDS DINOSAURS?

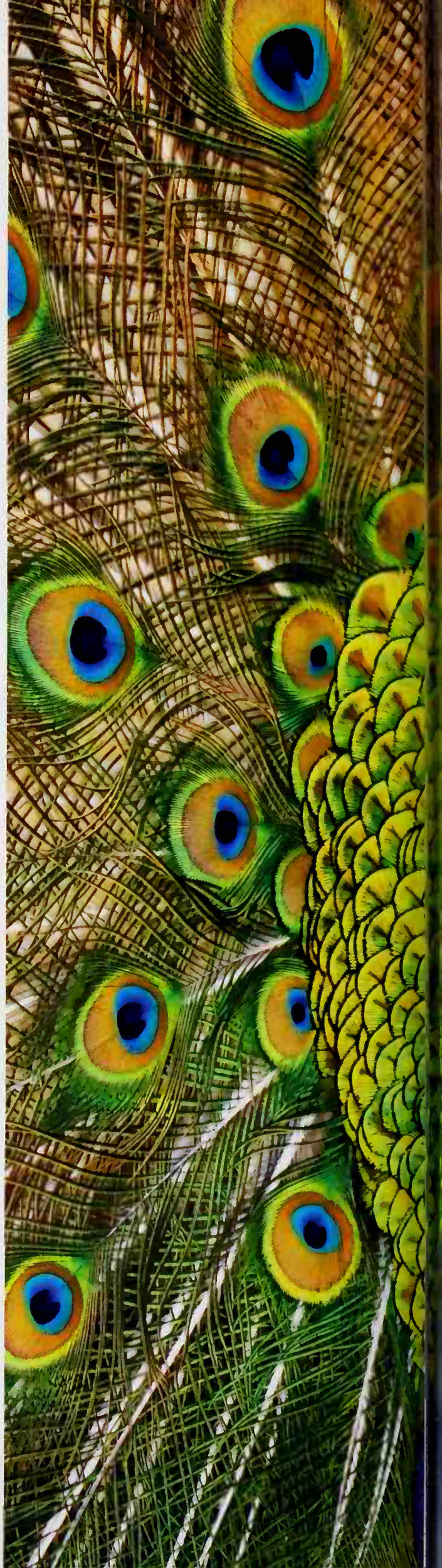
Traditionally birds are in a class separate from reptiles, including dinosaurs. But today scientists hold that all descendants of a common ancestor should be classified together to reflect evolutionary relationships, a method known as cladistics. This makes birds as much part of the dinosaur group as *Tyrannosaurus*.

Birds are the only living animals with feathers. They are warm-blooded vertebrates that stand on two legs and their forelimbs are considerably modified as wings. In addition to facilitating flight, feathers insulate the body, so many birds stay active in ice-cold conditions, just like furry mammals. Feathers can also be colorful, showing that birds rely on flaunting visual cues to communicate and find a mate. Birds evolved from a group of two-legged, carnivorous dinosaurs that included *Tyrannosaurus*. It is possible—even likely—that these ancestors were already feathered.

TAKING TO THE AIR

No one knows for sure how—or why—the first birds took to the air, but the fact that they did had effects that would be forever imprinted upon the bird's body. Their wristbones became fused together as arms evolved into wings. The breastbone evolved a huge keel for the attachment of larger muscles for powering the flapping wings. Already their dinosaur ancestors had lightweight, air-filled bones. But birds coupled this with a strong cardiovascular system powered by a mammal-like four-chambered heart and a rapid metabolism to generate lots of energy. A system of air sacs—linked to the bone chambers—expanded their breathing capacity to flush stale air out of lungs more efficiently than in mammals.

Many reptilian features still remain. The bare parts of a bird's legs and toes have horny reptilian scales. Birds excrete a semisolid waste product called uric acid (not a solution of urea, as in mammals). Waste from the kidneys and gut mix and exit via a common reptilian opening called a cloaca. But a bird's brain is better developed than that of a reptile, because it is supported by a warm-blooded body and fast metabolism. This makes birds not only skilled at flying, but remarkably sophisticated in the ways they acquire food or raise a family. Young birds hatch from reptilian hard-shelled eggs, but they are reared by intelligent parents who will invest much time and energy into raising them to maturity. Sixty million years of evolution mean that a bird is no longer just a reptile with feathers.



THE PEACOCK'S DAZZLING DISPLAY >
The feathers of many birds are vibrantly colored, used as striking signals in courtship and other social interactions.

BIRD GROUPS

The 29 orders range from heavy-bodied ground-dwellers—a few of which are incapable of flight—to true masters of the air, such as soaring albatrosses, dive-bombing falcons, and hovering hummingbirds.

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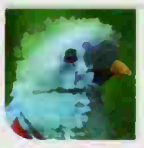

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TINAMOUS

The ground-dwelling tinamous from Central and South America resemble Old World partridges, but they are most closely related to ratites.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	TINAMIFORMES
FAMILIES	1
SPECIES	47

Tinamous, the sole family in the order Tinamiformes, are small, ground-dwelling birds with rounded bodies and short legs. All have very short tails, which gives them a dumpy appearance, and some species are crested.

Unlike the ratites, tinamous have a ridged breastbone for the attachment of flight muscles, a feature that is seen in all other birds. Their wings are much better developed than those of the ratites, and they can fly, although only over short distances. Usually they are reluctant to take to the air and prefer instead to run away from predators. Tinamous have comparatively small a heart and lungs, which perhaps explains why these birds become exhausted so easily.

Some groups of tinamous inhabit woodlands and forest, while others are found in open grassland. All feed on seeds, fruit, insects, and sometimes small vertebrates. The cryptic plumage patterns of most species makes them difficult to spot in the wild, and they are more likely to be recognized by their distinctive calls.

BEAUTIFUL EGGS

Male tinamous mate with many different females, and it is the males that tend the eggs and young. The nests are made in leaf litter on the ground. Tinamou eggs—brightly colored turquoise, red, or purple—have a porcelain-like gloss.

DEBATE

ORIGINS OF TINAMOUS

Traditionally, tinamous are grouped separately from the flightless ratites. But the two groups share a pattern of skull bones not found in other birds, suggesting that they have a common ancestor. Scientists are not certain whether this ancestor was flightless or able to fly; the latter is more likely.

ELEGANT CRESTED TINAMOU
Eudromia elegans
F: Tinamidae
This bird of high-altitude shrubland occurs from southern Chile to Argentina. Unlike other tinamou species, it often lives in flocks.

ORNATE TINAMOU
Nothoprocta ornata
F: Tinamidae
An Andean tinamou, this species is found on the high montane grasslands of western South America from Peru to northern Argentina.

RATITES

A group that includes the largest living birds, the ratites are flightless and strong-footed. Some flock in open habitats; others live alone in forests.

PHYLUM	CHORDATA
CLASS	AVES
ORDERS	4
FAMILIES	5
SPECIES	15

Ratites evolved in the Southern Hemisphere and there is evidence to suggest they have flying ancestors. They lack some of the features associated with flight, but retain others. Ratites do not have the bony ridge on their breastbone that anchors powerful flight muscles in other birds, but they still have wings, and the part of the brain that controls flight is well developed.

The ostriches, which make up the order Struthioniformes, are found in dry open areas in Africa. They are powerful-limbed birds that can run at high speed on flat ground. Somewhat similar in appearance, though less massively built, are the rheas—the order Rheiformes—from the grasslands of South America. Like most ratites, both these groups of birds have a reduced number of toes: the rhea has three toes, the ostrich only two. Both have large wings that they use in displays or to assist their balance when sprinting.

AUSTRALASIAN SPECIES

The Australasian ratites include the cassowaries and emus of the order Casuariiformes and the kiwis, the Apterygiformes. All are forest birds, except the emu, which inhabits scrubland and grassland. The tiny wings of these ratites are invisible under their plumage, which resembles shaggy hair rather than feathers. The nocturnal kiwis, familiar as the national symbol of New Zealand, are the only ratites that do not have a reduced number of toes.

The male ostrich scrapes out a shallow nest in the ground, in which his harem of females lay up to 50 eggs.

NORTH ISLAND KIWI
Apteryx mantelli
F: Apterygidae
One of several New Zealand kiwis, this nocturnal ratite detects buried invertebrate prey by smell, using nostrils at its probing bill tip.

TOKOEKA
Apteryx australis
F: Apterygidae
This is the South Island cousin of *A. mantelli*. Lighter colored than its relative, it has been recognized as a separate species after DNA analysis.

helmetlike casque
coarse, shaggy plumage
red wattles
5–6 ft
1.5–1.8 cm

SOUTHERN CASSOWARY
Casuarius casuarius
F: Casuariidae

Cassowaries are fruit-eating rain forest birds. With a range that extends through New Guinea and northern Australia, this is the most widespread species of its family.

brown plumage
5½–7 ft
1.7–2.1 cm

EMU
Dromaius novaehollandiae
F: Dromaiidae

Australia's largest living bird is found across the continent in open grassy areas. Like the related cassowary, its chicks are striped for camouflage.

almost bare neck
black body plumage
white primary feathers
5½–8¾ ft
1.7–2.7 cm
♂

OSTRICH
Struthio camelus
F: Struthionidae

The largest bird in the world, the ostrich lives in savanna and semidesert areas of Africa. Breeding males mate with several females.

large eye
scaly legs
featherless thighs
grayish brown plumage
♀
two-toed feet

3–3½ ft
92–100 cm

LESSER RHEA
Pterocnemia pennata
F: Rheidae

Smaller than the greater rhea, its northern cousin, this ratite inhabits the southern Andes and Patagonia, where it lives in small flocks.

4¾–4½ ft
127–140 cm

GREATER RHEA
Rhea americana
F: Rheidae

This central South American ratite has a breeding system that does not involve pair-bonding. Males tend a large nest of eggs produced by many females.

gray neck
5½–8¾ ft
1.7–2.7 cm

SOMALI OSTRICH
Struthio camelus molydophanes
F: Struthionidae

Separated from other populations of ostrich by the Rift Valley, the East African gray-necked form is sometimes regarded as a separate species.

26–28 cm
65–70 cm

GREAT SPOTTED KIWI
Apteryx haastii
F: Apterygidae

One of two species of kiwis with gray mottled plumage, this bird is confined to mountain areas of western South Island.

14–18 in
35–45 cm

LITTLE SPOTTED KIWI
Apteryx owenii
F: Apterygidae

Introduced mammals have driven this small kiwi to the edge of extinction. It survives on predator-free satellite islands around New Zealand.

FOWL, GAMEBIRDS, AND RELATIVES

Strong footed gamebirds are adapted to a wide range of habitats. They are primarily ground-dwellers and feed mostly on plants.

Although they may be good fliers, the majority of gamebirds, the order Galliformes, take to the air only when threatened. None, except the common and Japanese quails, sustains a long migratory flight. Most gamebirds spend their lives on the ground. Only the members of the curassow family of tropical America are habitual tree-dwellers; these birds make their nests in trees, too. Most primitive of the gamebird group are the big-footed megapodes of the Indo-Pacific forests. They bury their eggs in heaps of compost or in volcanic sand and rely on heat generated by decomposition or volcanic action to incubate them. All other gamebirds take a more active role in parenthood, although only the female raises the brood. The precocious offspring can run and feed themselves soon after hatching.

Male gamebirds often have flamboyant plumage, which they use in courtship displays to attract a harem of females. Some species are armed with leg spurs to battle with competitors.

DOMESTICATED SPECIES

The relative ease with which many gamebird species, including the turkey, can be kept in captivity has made them economically important in many countries. Domesticated chickens around the world are all descendants of the red junglefowl of Southeast Asia.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	GALLIFORMES
FAMILIES	5
SPECIES	290

DEBATE

WHAT IS A PARTRIDGE?

Traditional categories of birds may not reflect biological relationships. Many gamebirds are called partridges, but the European grey partridge differs subtly from others in that, for example, males are more distinctively patterned than females—perhaps making it a closer ally of pheasants.

22 in
55 cm

MALEO
Macrocephalon maleo
F: Megapodiidae

This megapode (large-footed bird) from Sulawesi Island in Indonesia lays its eggs in sand and relies on heat from the sun or underground volcanic activity for incubation.

28 in
70 cm

BRUSH TURKEY
Alectura lathami
F: Megapodiidae

Males of this eastern Australian megapode control the temperature of their incubation mounds by adding or removing rotting vegetation. More females hatch at high temperatures.

31–36 in
78–92 cm

GREAT CURASSOW
Crax rubra
F: Cracidae

Ranging from Mexico to Ecuador, this large curassow has a curly crest like other curassows. Males are black; females are brown.

black markings down the front of the throat

brown, white, and black wings

MALLEEFOWL
Leipoa ocellata
F: Megapodiidae

Like many megapodes, this southern Australian species makes a compost mound to lay its eggs. It feeds primarily on various seeds, but is thought to be omnivorous.

23½ in
60 cm

33 in
84 cm

BARE-FACED CURASSOW
Crax fasciolata
F: Cracidae

This South American curassow has a sparsely feathered face. Unlike other related species, it has no fleshy wattles or bill knob.

gray-brown upperparts

olive-brown breast

white-tipped tail

19–21 in
48–53 cm

PLAIN CHACHALACA
Ortalis vetula
F: Cracidae

Ranging from Texas to Costa Rica, this northernmost member of the American curassow family is the only one found in the USA.

18 in
46 cm

GREY-HEADED CHACHALACA
Ortalis cinereiceps
F: Cracidae

Named for their calls, chachalacas are brown relatives of curassows. This species lives in scrubby habitat from Honduras to Colombia.

27 in
69 cm

BLUE-THROATED PIPING GUAN
Pipile cumanensis
F: Cracidae

This South American bird has glossy black plumage typical of tree-dwelling piping guans. They are named for their shrill breeding calls.

23–26 in
59–65 cm

HIGHLAND GUAN
Penelopina nigra
F: Cracidae

This Central American bird is more ground-dwelling than other guans. It is perhaps the only member of its family that nests on the ground.

22 in
55 cm

BEARDED GUAN
Penelope barbata
F: Cracidae

Named for its streaked neck, the bearded guan, like related species in this genus, is a rain forest bird. It is found in Ecuador and Peru.

26–30 in
66–76 cm

SPIX'S GUAN
Penelope jacquacu
F: Cracidae

This S. American species belongs to a group of brown guans that resemble chachalacas, but have shorter legs. It nests in trees and has a loud mating call.

26–30 in
67–75 cm

30 in
76 cm

CAUCA GUAN
Penelope perspicax
F: Cracidae

A bronze-sheened relative of the spix's guan, this bird is found only in the Cauca Valley region in the western and northern parts of Colombia.

bare bluish head

24–28 in
61–71 cm

cape of long feathers

VULTURINE GUINEAFOWL
Acryllium vulturinum
F: Numididae

Guineafowl are African gamebirds that live in groups, but are monogamous. They all have bare heads. This is the largest guineafowl species and is found in eastern Africa.

red throat wattle

27–30 in
68–75 cm

DUSKY-LEGGED GUAN
Penelope obscura
F: Cracidae

The only brown guan with dark rather than reddish legs, this species occurs in central South America, from Brazil to northern Argentina.

CHESTNUT-BELLIED GUAN
Penelope ochrogaster
F: Cracidae

The throat wattle that is typical of brown guans is especially well developed in this species from south-central Brazil.

26–34 cm
10–13 in

MOUNTAIN QUAIL
Oreortyx pictus
F: Odontophoridae

This native of the Rocky Mountains, like other American quails, is a ground-nesting, monogamous species.

9½–10½ in
24–27 cm

CALIFORNIAN QUAIL
Callipepla californica
F: Odontophoridae

Found from Oregon to California, this species is characterized by its forward-drooping crest, comprised of a clutter of six feathers.

10 in
25 cm

GAMBEL'S QUAIL
Callipepla gambelii
F: Odontophoridae

This relative of the Californian quail has a longer crest. It occurs in the desert in the south of California and the ranges of the two do not overlap.

»

» FOWL, GAMEBIRDS, AND RELATIVES

12½–14 in
32–35 cm

black stripes on flanks

CHUKAR PARTRIDGE
Alectoris chukar
F: Phasianidae

With a range extending across central Eurasia, this is the most widespread of the red-legged partridges—typically birds of dry country, with striking black markings.

15 in
38 cm

ARABIAN PARTRIDGE
Alectoris melanocephala
F: Phasianidae

This large red-legged partridge occurs in semi-desert regions of the Arabian Peninsula and Yemen. Its preferred habitat is juniper woodland.

8½ in
21 cm

CHESTNUT-BELLIED HILL PARTRIDGE
Arborophila javanica
F: Phasianidae

Found in Southeast Asian rain forests, hill partridges are small, cryptically colored gamebirds with stumpy tails. Many have distinctive head markings.

11½–12½ in
29–32 cm

GRAY PARTRIDGE
Perdix perdix
F: Phasianidae

This is the most widespread of a small genus of dark-bellied Eurasian gamebirds that are more related to pheasants than other partridges.

11–12 in
28–30 cm

GREY FRANCOLIN
Francolinus pondicerianus
F: Phasianidae

As with related junglefowl, males of this southern Asian francolin have leg spurs that they use in fighting.

10–15 in
25–38 cm

RED-NECKED FRANCOLIN
Francolinus afer
F: Phasianidae

A ground-nesting bird of forest and grassland, this species is widespread through Africa, from the Democratic Republic of Congo to the Cape.

10 in
26 cm

ROULROUL
Rollulus rouloul
F: Phasianidae

Related to hill partridges, the Southeast Asian roulroul has a more colorful plumage. Males are dark blue and have a reddish crest; females are green and lack the crest.

12 in
31 cm

CHINESE BAMBOO PARTRIDGE
Bambusicola thoracicus
F: Phasianidae

There are two species of bamboo partridge, birds of eastern Asia that are related to francolins and junglefowl. This bird is native to China.

6½–7 in
16–18 cm

COMMON QUAIL
Coturnix coturnix
F: Phasianidae

Unlike other gamebirds, this tiny species of western Eurasian grasslands and semi-desert is migratory in the northern parts of its range.

15½–16 in
39–40 cm

black throat

SPRUCE GROUSE
Canachites canadensis
F: Phasianidae

Like other woodland grouse, this North American species can digest the needles of conifer and spruce trees, rejected by most animals.

16–20 in
40–50 cm

SOOTY GROUSE
Dendragapus obscurus
F: Phasianidae

One of several North American grouse that have an inflatable neck sac, this dark-colored species inhabits the pine forests of the Pacific coast.

16–18½ in
41–47 cm

SHARP-TAILED GROUSE
Tympanuchus phasianellus
F: Phasianidae

This N. American grouse is a more widespread, more northerly cousin of prairie chickens. Males have purple sacs for display.

17 in
43 cm

GREATER PRAIRIE CHICKEN
Tympanuchus cupido
F: Phasianidae

This species is from the central USA. As with other species of prairie chicken, males engage in group courtship displays by inflating their colored neck sacs.

15–16 in
38–41 cm

LESSER PRAIRIE CHICKEN
Tympanuchus pallidicinctus
F: Phasianidae

Found in southern N. America, this small species of prairie chicken has a colored neck sac and drumming call, typical of *Tympanuchus* grouse.

23½–34 in
60–87 cm

WESTERN CAPERCAILLIE
Tetrao urogallus
F: Phasianidae

Found in western Eurasian coniferous forests, this is the largest member of the grouse family. Males display to females with rattling, popping calls.

13½–14 in
34–36 cm

ROCK PTARMIGAN
Lagopus muta
F: Phasianidae

One of three related grouse that turn white in winter, the rock ptarmigan is a tundra and mountain bird with a circumpolar distribution.

15–16 in
38–41 cm

RED GROUSE
Lagopus lagopus scotica
F: Phasianidae

Unlike most ptarmigans, this British race of the circumpolar willow grouse does not turn white in winter.

23½–28 in
60–70 cm

SATYR TRAGOPAN
Tragopan satyra
F: Phasianidae

This is a Himalayan species of *Tragopan*, a genus of Asian tree-nesting pheasants. Male tragopans have expandable fleshy lappets and horns that are used for display.

16–20 in
40–50 cm

PALAWAN PEACOCK-PHEASANT
Polyplectron napoleonis
F: Phasianidae

Male peacock-pheasants lack the long plumes of their peafowl relatives, but display tail feathers marked with iridescent eyespots.

2½–7¼ ft
0.8–2.2 m

INDIAN PEAFOWL
Pavo cristatus
F: Phasianidae

This tropical Asian species occurs in India and Sri Lanka. Males court females by raising their long plumes, which are just above the tail.

16–31 in
41–78 cm

RED JUNGLEFOWL
Gallus gallus
F: Phasianidae

Unlike related francolins, males of this Asian ancestor of domestic chickens mate with many females. They have combs and wattles, which are absent in females.

21–35 in
53–89 cm

COMMON PHEASANT
Phasianus colchicus
F: Phasianidae

Native to the woodlands of central and eastern Eurasia, this species has been introduced into western Europe, where it is now common in farmland.

pale gray tail feathers

KALIJ PHEASANT
Lophura leucomelanos
F: Phasianidae

This pheasant occurs in forests from the Himalayas to Myanmar. There is also an introduced population in the Hawaiian Islands.

23½–32 in
60–80 cm

SIAMESE FIREBACK
Lophura diardi
F: Phasianidae

Like many pheasants, this S.E. Asian bird has bare, red facial skin. As with other species of *Lophura*, this feature is common to both sexes.

23½–47 in
60–120 cm

white-tipped tail fanned in display

LADY AMHERST'S PHEASANT
Chrysolophus amherstiae
F: Phasianidae

Like many other pheasants, only males of this species have spectacular plumage, and only females care for the young. This bird is from China and Myanmar.

bald head

3½–4 ft
1.1–1.3 m

WILD TURKEY
Meleagris gallopavo
F: Phasianidae

Turkeys are large, wattled gamebirds native to N. America. This species from the southern USA is the ancestor of domesticated turkeys.

WATERFOWL

Species in this group are web-footed birds adapted for surface swimming. The majority feed on plants, although some take small aquatic animals.

Most waterfowl have short legs set well back on the body. These birds, the Anseriformes, swim by propelling themselves with webbed feet, and all have plumage kept waterproofed with oil taken from a gland near the tail. South American screamers and magpie-goose from Australasia have partially webbed feet, spending much of their time on land or wading in marshes. These birds belong to two ancient families. All other waterfowl are classified in a single family, the most primitive group being the whistling ducks.

SWANS, GEESE, AND DUCKS

In swans and geese, the sexes have similar plumage patterns. These long-necked, long-winged birds occur mostly outside the tropics. Many northern species breed close to the Arctic and migrate southwards to overwinter. Ducks are generally smaller and have shorter necks than others in this group. Unlike geese and swans, male ducks are usually more brightly plumaged than the females, especially when breeding. Both sexes of many duck species have a vividly colored wing-patch called a speculum.

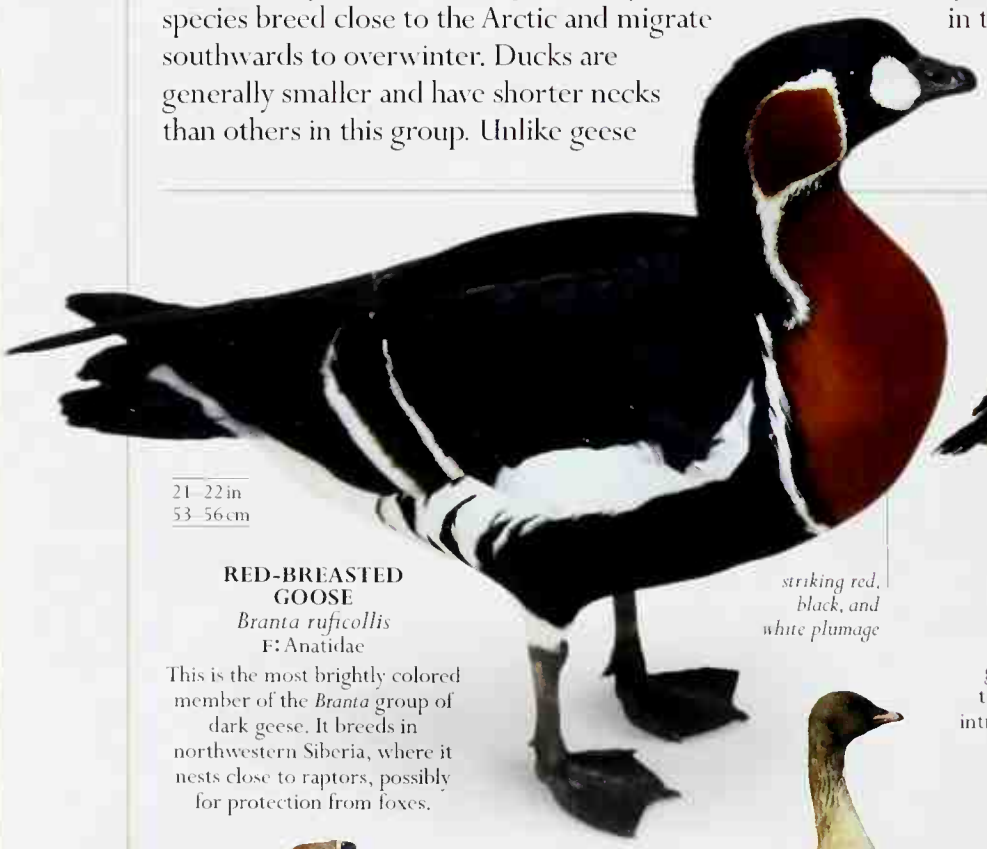
The typical "duckbills" of waterfowl have internal plates that have evolved to strain aquatic food drawn in by a muscular tongue. All species retain this feature, even though some have adopted different feeding methods. Geese graze on grasslands, but swans are more aquatic and use their long necks to plunge their heads deep in water. Many ducks dabble – up-ending to feed on or just below the water surface. Others, such as pochards, dive under water to gather food. The saw-billed ducks have narrow bills with serrated edges to catch fish. One group of ducks, including eiders, scoters, and mergansers, includes accomplished sea divers.

NESTING

Most waterfowl are monogamous, some pairing for life. They nest largely on the ground, but a few nest in trees. The marine ducks come inland to breed. All waterfowl produce downy chicks that can walk and swim soon after hatching.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	ANSERIFORMES
FAMILIES	3
SPECIES	174

Flying in formation reduces air drag, enabling birds like these snow geese to conserve energy on long migrations.



21–22 in
53–56 cm

RED-BREASTED GOOSE
Branta ruficollis
F: Anatidae

This is the most brightly colored member of the *Branta* group of dark geese. It breeds in northwestern Siberia, where it nests close to raptors, possibly for protection from foxes.

striking red, black, and white plumage

20–43 in
50–110 cm

CANADA GOOSE
Branta canadensis
F: Anatidae

The largest of the *Branta* geese, this species is native to N. America, but has been introduced to northern Europe.

23–28 in
58–71 cm

BARNACLE GOOSE
Branta leucopsis
F: Anatidae

This goose breeds on Arctic tundra in Greenland and Russia, where it avoids predators by nesting on cliff tops.

22–28 in
56–71 cm

HAWAIIAN GOOSE
Branta sandvicensis
F: Anatidae

Confined to the Hawaiian Islands, this goose has reduced foot-webbing and strong claws, and is adapted to climbing on to rocky lava flows.

32–37 in
81–94 cm

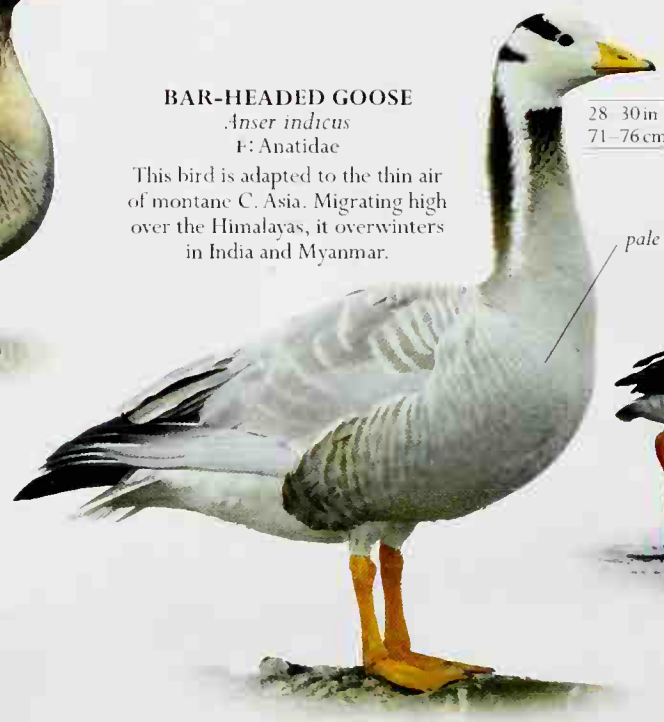
CHINESE GOOSE
Anser cygnoides
F: Anatidae

Widely domesticated, this goose is threatened in the wild in its native C. Asia, where it occurs on the steppes.

23½–30 in
60–75 cm

PINK-FOOTED GOOSE
Anser brachyrhynchus
F: Anatidae

This small, grey goose breeds on rocky outcrops of tundra in Greenland and Iceland, and overwinters in western Europe.



28–30 in
71–76 cm

BAR-HEADED GOOSE
Anser indicus
F: Anatidae

This bird is adapted to the thin air of montane C. Asia. Migrating high over the Himalayas, it overwinters in India and Myanmar.

pale gray body

30–35 in
76–89 cm

GREYLAG GOOSE
Anser anser
F: Anatidae

Widespread across the grasslands and wetlands in Eurasia, this typical grey *Anser* goose is the wild ancestor of domesticated geese.

EMPEROR GOOSE
Anser canagicus
F: Anatidae

Found in northeastern Siberia and Alaska, this goose grazes on coastal grass and seaweed. It is less gregarious than most other geese.

ASHY-HEADED GOOSE
Chloephaga poliocephala
F: Anatidae

S American *Chloephaga* geese are perhaps more related to ducks than to other geese. This species occurs in Chile and Argentina. Like others in its genus, it may perch in trees.

EGYPTIAN GOOSE
Alopochen aegyptiaca
F: Anatidae

Belonging to a group of southern hemisphere geese that are related to ducks, the Egyptian goose is widespread through Africa.

PLUMED WHISTLING DUCK
Dendrocygna eytoni
F: Anatidae

Distinct from geese and true ducks, whistling ducks are named for their unique call. This is an Australian species.

MAGPIE-GOOSE
Anseranas semipalmata
F: Anseranatidae

From Australian wetlands, this species has long legs and partially webbed feet. It is not closely related to any other waterfowl.

CAPE BARREN GOOSE
Cereopsis novaehollandiae
F: Anatidae

This distinctive goose is restricted to southern Australia and offshore islands, where it gathers in small flocks and grazes on grassland.

BLUE-WINGED GOOSE
Cyanochen cyanoptera
F: Anatidae

This goose has a thick plumage as an adaptation to the cool highlands of its native Eritrea and Ethiopia.

COSCOROBA SWAN
Coscoroba coscoroba
F: Anatidae

Resembling a goose, this is the smallest of swans. It is confined to swamps in the southern parts of Chile and Argentina.

BLACK SWAN
Cygnus atratus
F: Anatidae

This sooty-black swan with white wing tips may nest in huge colonies. Native to Australia and Tasmania, it has been introduced to New Zealand, Europe, and North America.

TRUMPETER SWAN
Cygnus buccinator
F: Anatidae

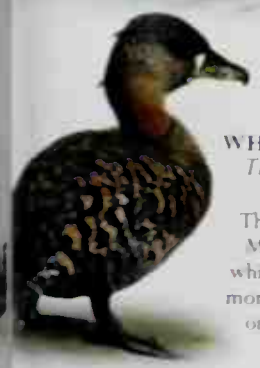
Related to other vocal swans, such as the Eurasian whooper swan (*C. cygnus*), this North American species has a loud, honking call.

MUTE SWAN
Cygnus olor
F: Anatidae

This species breeds in Europe and central Asia. Like other swans, it grazes on underwater vegetation by submerging its head.

BLACK-NECKED SWAN
Cygnus melancoryphus
F: Anatidae

Found in southern South America, this species spends more time on water than other swans and nests on floating vegetation.



WHITE-BACKED DUCK
Thalassornis leuconotus
F: Anatidae

This bird from Africa and Madagascar is related to whistling ducks, but spends more time on water, nesting on islands of vegetation.

AFRICAN PYGMY-GOOSE
Nettapus auritus
F: Anatidae

Like other pygmy-geese, this African species nests in tree hollows. It is usually found in wetlands with water lilies, on which it feeds.

ORINOCO GOOSE
Neochen jubata
F: Anatidae

A South American relative of ducks, this goose occurs on tropical wet savanna and forest edges along rivers.

SOUTHERN SCREAMER
Chauna torquata
F: Anhimidae

Screamers are large, bulky birds that live in South American marshlands. Like other screamers, this species has bony wing spurs that may be used in fighting.

»

18–22 in
45–56 cm

AMERICAN WIGEON
Anas americana
F: Anatidae

This species feeds by dabbling on the surface of shallow waters and occasionally up-ends. Huge flocks winter in the Caribbean after breeding in North America.

cream, black, and green head pattern

15½–17 in
39–43 cm

BAIKAL TEAL
Anas formosa
F: Anatidae

This distinctive duck breeds in cold, open forest in Siberia on the edge of the tundra, and migrates to Southeast Asia in the winter.

17–22 in
43–56 cm

NORTHERN SHOVELER
Anas clypeata
F: Anatidae

Both sexes of dabbling (surface-feeding) ducks typically have a colored wing-patch called a speculum. This widespread wetland species of the northern hemisphere has a green speculum.

♀

20–26 in
50–65 cm

♂

MALLARD
Anas platyrhynchos
F: Anatidae

Widespread in the northern hemisphere, the surface-feeding mallard can interbreed with related species, perhaps indicating that this group has only recently evolved.

22–26 in
55–65 cm

INDIAN RUNNER
Anas platyrhynchos
F: Anatidae

A domestic descendant of the wild mallard, this long-necked breed originated in the Malay Peninsula and India in the 19th century.

15–20 in
38–51 cm

WHITE-CHEEKED PINTAIL
Anas bahamensis
F: Anatidae

This saltwater dabbling duck is found in S. American estuaries and mangrove swamps. Unlike temperate northern pintails, the sexes look alike.

20–26 in
50–65 cm

DOMESTIC DUCK
Anas platyrhynchos
F: Anatidae

Most domesticated ducks have descended from the mallard. They are raised for their meat, eggs, or down, or kept for ornamental purposes.

13–16 in
33–40 cm

BUFFLEHEAD
Bucephala albeola
F: Anatidae

The smallest sea duck in North America, the bufflehead nests in tree-holes and sometimes uses those vacated by woodpeckers.

orange cheek plumes

16–20 in
41–51 cm

MANDARIN DUCK
Aix galericulata
F: Anatidae

Wrongly thought to be monogamous, this tree-nesting duck is a symbol of love in its native northeastern Asia. It has been introduced in Europe and California.

15–20 in
38–51 cm

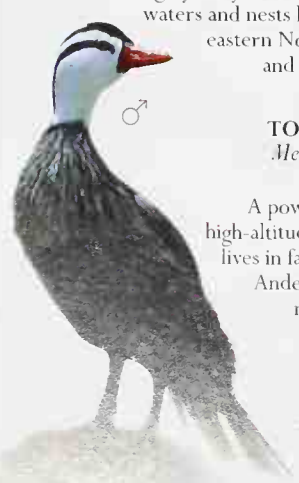
HARLEQUIN DUCK
Histrionicus histrionicus
F: Anatidae

A highly buoyant sea duck, this species rides choppy waters and nests beside fast-flowing streams in eastern North America, Iceland, and western Russia.

17–20 in
43–51 cm

WOOD DUCK
Aix sponsa
F: Anatidae

The newly hatched chicks of this North American tree-perching duck jump down from their nests in high tree-holes to reach the water below.



♂

TORRENT DUCK
Merganetta armata
F: Anatidae

A powerful swimmer, this high-altitude, South American duck lives in fast-flowing rivers of the Andes and nests beneath riverside rocks.

17–18 in
43–46 cm

♀

14–15 in
35–38 cm

RINGED TEAL
Callonetta leucophrys
F: Anatidae

Like other tropical ducks, this South American teal is not migratory and retains its plumage colors throughout the year.

white flank patch

18–22 in
46–55 cm

SURF SCOTER
Melanitta perspicillata
F: Anatidae

The North American surf scoter, like other scoter species, breeds near fresh water and winters at sea. The male's body is entirely black.

16½–20 in
42–50 cm

HOODED MERGANSER
Lophodytes cucullatus
F: Anatidae

Found in North America, this bird has a saw-edged bill for catching fish. It dives with powerful kicks of the feet.

18–22 in
46–54 cm

white cheek patch

SPECTACLED DUCK
Speculanas specularis
F: Anatidae

This duck is found along the rivers of S. America. It is locally called "dog duck" after the barking call of the female.

14–18 in
36–45 cm

PINK-EARED DUCK
Malacorhynchus membranaceus
F: Anatidae

The pink head spot of this widespread Australian species is less distinctive than its zebra pattern. It consumes plankton, strained from water by beak flaps.

14–17 in
35–43 cm

RUDDY DUCK
Oxyura jamaicensis
F: Anatidae

This North American duck, now introduced in Europe, has a stiff tail which it uses as a rudder when diving.

16–18½ in
40–47 cm

TUFTED DUCK
Aythya fuligula
F: Anatidae

A Eurasian member of the pochard group, the tufted duck feeds mostly, though not entirely, on invertebrates in contrast to its largely vegetarian relatives.

19–24 in
48–61 cm

CANVASBACK
Aythya valisineria
F: Anatidae

This North American bird is the largest species of pochards, a group of ducks with typically stocky bodies and large heads.

15–23 in
38–58 cm

LONG-TAILED DUCK
Clangula hyemalis
F: Anatidae

Unlike most other Arctic sea ducks, the long-tailed duck breeds in saltwater as well as freshwater habitats. Males have a distinctive long tail.

14–17½ in
35–44 cm

SMEW
Mergellus albellus
F: Anatidae

A member of the group of cavity-nesting mergansers, this species is the only small white duck found in northern Eurasia.

24–25 in
61–63 cm

COMMON SHELDUCK
Tadorna tadorna
F: Anatidae

This goose-like duck is largely a coastal resident in Europe, but in Asia it migrates southwards from inland regions during winter. It nests in burrows.

20½–23 in
52–58 cm

RED-BREASTED MERGANSER
Mergus serrator
F: Anatidae

Widespread across the northern hemisphere, the red-breasted merganser breeds on coasts and spends more time at sea than other mergansers.

orange head lobe

17–25 in
43–63 cm

KING EIDER
Somateria spectabilis
F: Anatidae

This bird breeds along Arctic tundra coastlines. Its large body size may help it to dive deeply for invertebrate prey.

rose blush on breast

22 in
55–56 cm

ROSYBILL
Netta peposaca
F: Anatidae

This S. American duck is related to the diving pochards, but spends more time feeding at the water surface. Only the males have a red bill.

20–24 in
51–61 cm

CRESTED DUCK
Lophonetta specularioides
F: Anatidae

This Andean species is a possible relic of a South American lineage that was ancestral to more widespread dabbling ducks, such as the mallard.

17–19 in
43–48 cm

STELLER'S EIDER
Polysticta stelleri
F: Anatidae

Like other related sea ducks of Arctic and subarctic regions, this eider overwinters farther south in huge flocks, sometimes numbering 20,000 birds.

PENGUINS

With their two-toned plumage, erect posture, and waddling walk, penguins are instantly recognizable as the classic symbol of the southern oceans.

Residents of the coastal regions of the Southern Hemisphere, all penguins are adapted to life in cold water. Most species live around islands encircling Antarctica, although some are found on southern coastlines of South America, Africa, and Australasia.

These flightless birds, order Sphenisciformes, probably descended from a common ancestor shared with the albatrosses. They may also be distant cousins of the loons of the Northern Hemisphere.

SPECIAL ADAPTATIONS

Penguins have legs set far back toward the tail, a feature that provides excellent propulsion in water and is seen also in birds such as loons and grebes. On land penguins walk upright, but with webbed feet placed flat on the ground their gait is ungainly. In common with other flightless birds, penguins have reduced wings, but these are modified in such a way that they can be used as flippers. In effect, penguins "fly" underwater.

A penguin's short, densely packed feathers have downy bases that trap warm air, and a layer of fat beneath the skin provides further insulation. The feather tips are greasy and waterproof, lubricated by oil produced from a large gland on the rump. A complex system of bloodflow through the legs and feet ensures that the penguin's body is not chilled by standing on snow or ice. The largest penguin species incubate their eggs on their feet. All penguins have counter-shaded plumage (dark above and pale below), which in the sea provides camouflage against ocean-going predators, such as leopard seals.

FORAGING AND NESTING

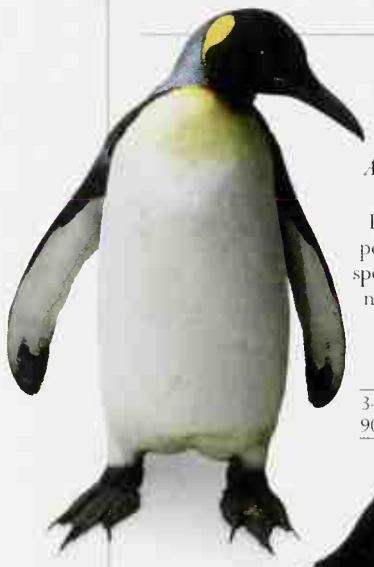
Penguins can dive for fishes, shrimps, and krill more than 200 times each day. When they have eggs to incubate and young to tend, the parents take turns foraging. In the case of emperor penguins, one of the few species to breed on the Antarctic, the males incubate the eggs alone throughout the polar winter while the females remain feeding at sea. Most penguins are colonial breeders and often return to the same nest site each season.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	SPHENISCIFORMES
FAMILIES	1
SPECIES	18

DEBATE

FLYING ANCESTORS?

In the early 20th century, flightless birds were popularly believed to be primitive. It was hoped that study of their embryos would reveal evidence of a direct link to a dinosaurian past. Penguin eggs became sought after, and members of Robert Falcon Scott's last expedition (1910–13) made a courageous journey to an emperor rookery in the bleak Antarctic winter. By the time the eggs they collected received scientific attention, the embryo theory had been disproved. Modern studies of anatomy, fossils, and DNA show that the ancestors of penguins, and other flightless birds, could fly.



KING PENGUIN
Aptenodytes patagonicus
F: Spheniscidae

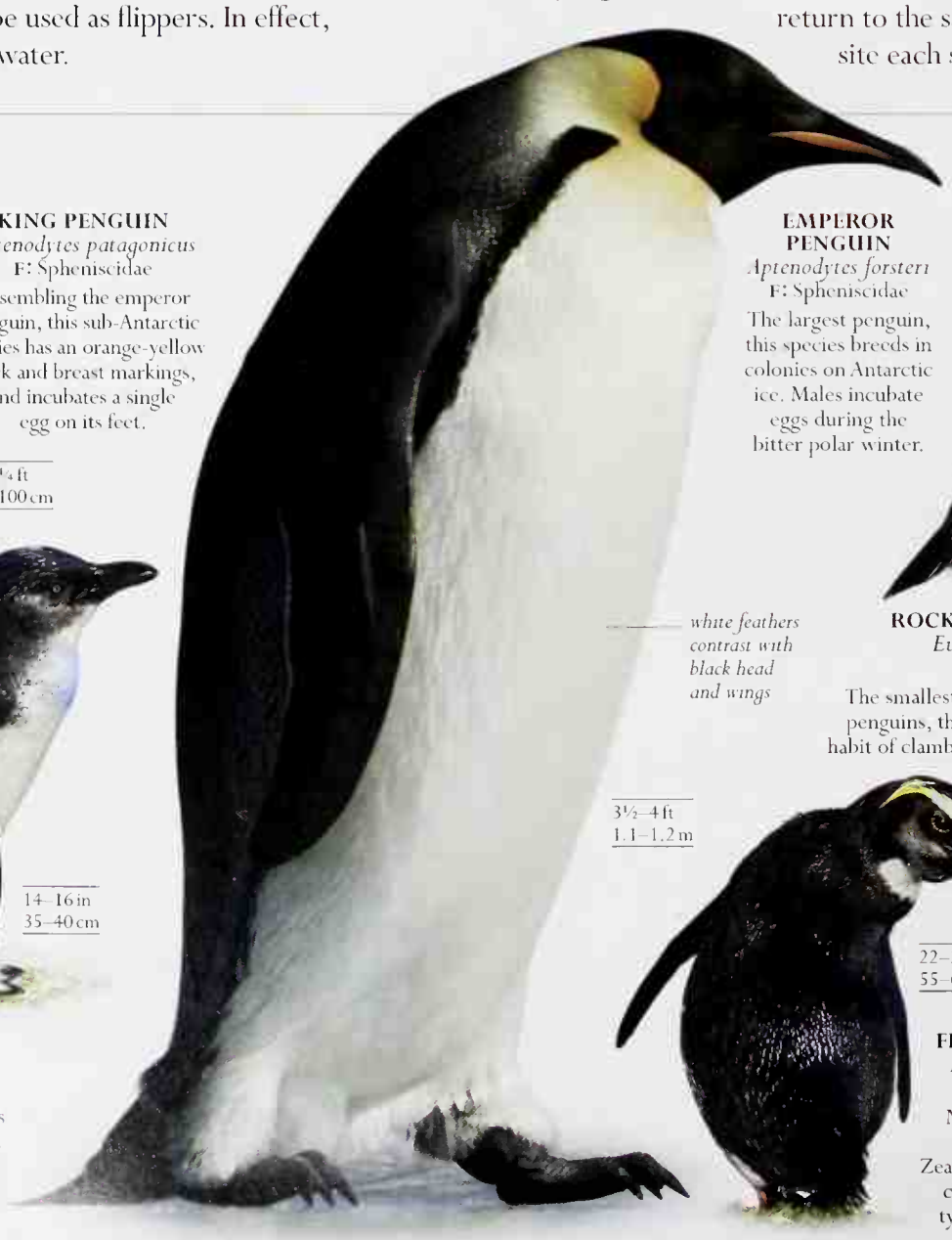
Resembling the emperor penguin, this sub-Antarctic species has an orange-yellow neck and breast markings, and incubates a single egg on its feet.

3–3¼ ft
90–100 cm

14–16 in
35–40 cm

LITTLE PENGUIN
Eudyptula minor
F: Spheniscidae

A burrow-nester, this bird is the smallest of all penguins. It occurs along the coasts of southern Australia and New Zealand.



white feathers contrast with black head and wings

3½–4 ft
1.1–1.2 m

EMPEROR PENGUIN
Aptenodytes forsteri
F: Spheniscidae

The largest penguin, this species breeds in colonies on Antarctic ice. Males incubate eggs during the bitter polar winter.

18–23 in
45–58 cm

yellow plume

ROCKHOPPER PENGUIN
Eudyptes chrysocome
F: Spheniscidae

The smallest of the sub-Antarctic crested penguins, this bird gets its name from its habit of clambering over rocks and boulders.

22–23½ in
55–60 cm

FIORDLAND PENGUIN
Eudyptes pachyrhynchus
F: Spheniscidae

Nesting in the cool coastal forests of southern New Zealand, this species has hairlike crest feathers and a red bill typical of *Eudyptes* penguins.

28 in
70 cm

MACARONI PENGUIN
Eudyptes chrysolophus
F: Spheniscidae

This bird inhabits islands in the far southern Atlantic and Indian oceans but is the only crested penguin to breed on the Antarctic Peninsula.

stubby bill
white eye ring
18–30 in
46–75 cm

ADELIE PENGUIN
Pygoscelis adeliae
F: Spheniscidae
One of three "brush-tailed" *Pygoscelis* penguins from Antarctica and adjacent islands, the Adelie penguin has a simple countershading that is typical of the genus.

28–32 in
71–80 cm

GENTOO PENGUIN
Pygoscelis papua
F: Spheniscidae
This penguin breeds on the Antarctic Peninsula and Southern Ocean islands. Its nest is a simple cluster of sticks, stones, and feathers.

CHINSTRAP PENGUIN
Pygoscelis antarcticus
F: Spheniscidae
The chinstrap penguin dives for krill and fish. It breeds on Antarctic coasts and islands of the South Atlantic.

thin black streak across face
26–28 in
67–72 cm

30 in
75 cm

blue-black upperparts

YELLOW-EYED PENGUIN
Megadyptes antipodes
F: Spheniscidae
A cousin of *Eudyptes* crested penguins, this rare New Zealand bird nests in scrub, but not in dense colonies like the other *Eudyptes* penguins.

black face

GALAPAGOS PENGUIN
Spheniscus mendiculus
F: Spheniscidae
This is the only penguin to breed in tropical waters cooled by the Humboldt Current, which flows along the western coast of South America. It nests in rock crevices.

black breast band

19–20 in
48–51 cm

HUMBOLDT PENGUIN
Spheniscus humboldti
F: Spheniscidae
Found along the Pacific coast of southern South America, this species belongs to a group of burrow-nesters characterized by bold banded patterns from flanks to thighs.

26–28 in
65–70 cm

27–28 in
68–70 cm

MAGELLANIC PENGUIN
Spheniscus magellanicus
F: Spheniscidae
Closely related to the Humboldt penguin, this banded penguin lives in colonies around the southern tip of South America and the Falkland Islands.

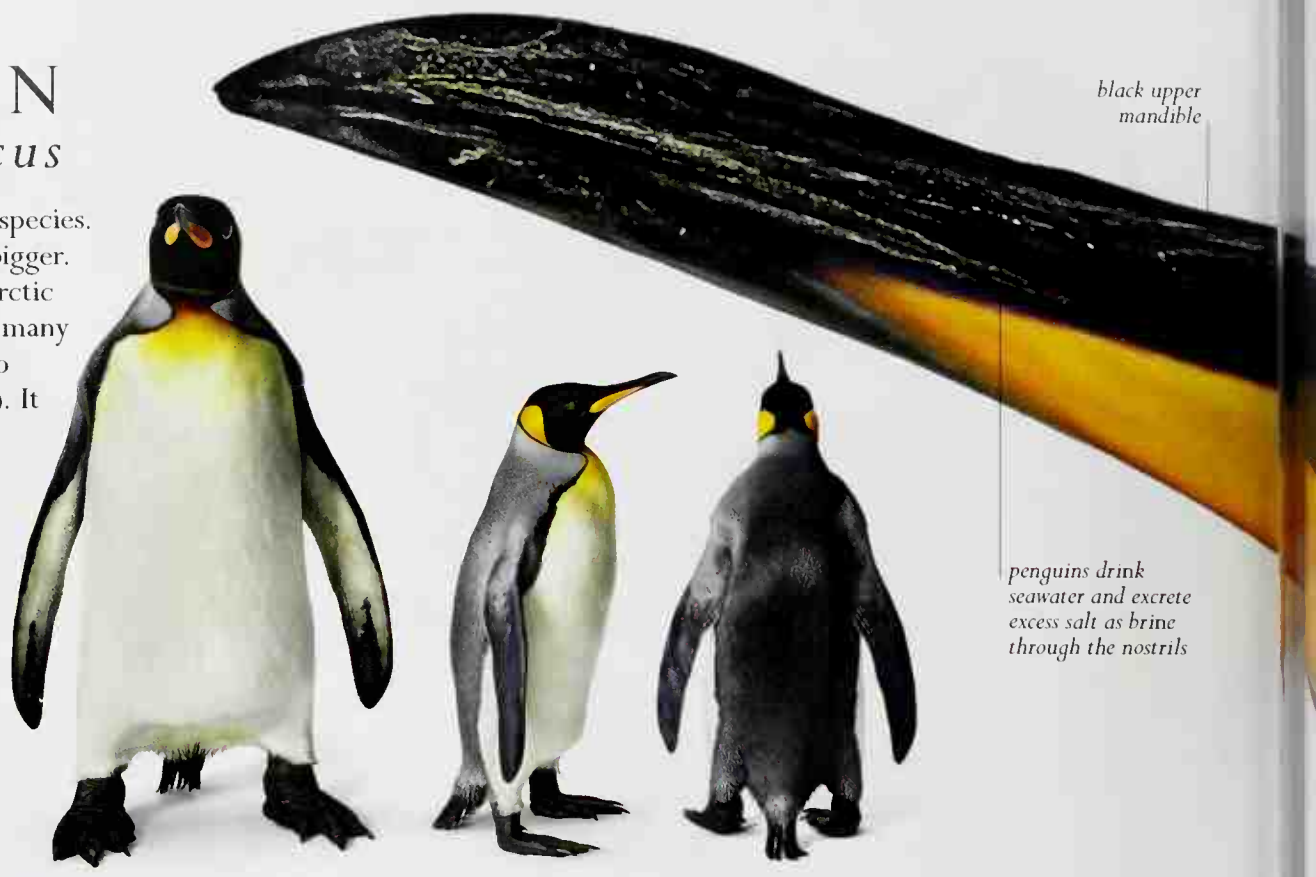
24–30 in
61–76 cm

JACKASS PENGUIN
Spheniscus demersus
F: Spheniscidae
Named for its donkeylike braying call, this bird is the only penguin to breed in Africa, in colonies on southwestern coasts.

KING PENGUIN
Aptenodytes patagonicus

The king penguin is the second largest penguin species. Only its close cousin, the emperor penguin, is bigger. Unlike the emperor, the king inhabits sub-Antarctic islands. It hunts fish, ignoring the krill taken by many of its rivals, and dives to extraordinary depths to get them—sometimes more than 660 ft (200 m). It produces just one egg at a time and takes more than a year to raise the single young. Because adults cannot breed annually, the enormous breeding colonies—containing juveniles of different ages—maintain a permanent presence on favored islands of the southern oceans.

SIZE 37–39 in (94–100 cm)
HABITAT Flat coastal plains and waters around sub-Antarctic islands
DISTRIBUTION Islands of S. Atlantic and S. Indian Oceans
DIET Mostly lanternfish, occasionally squid

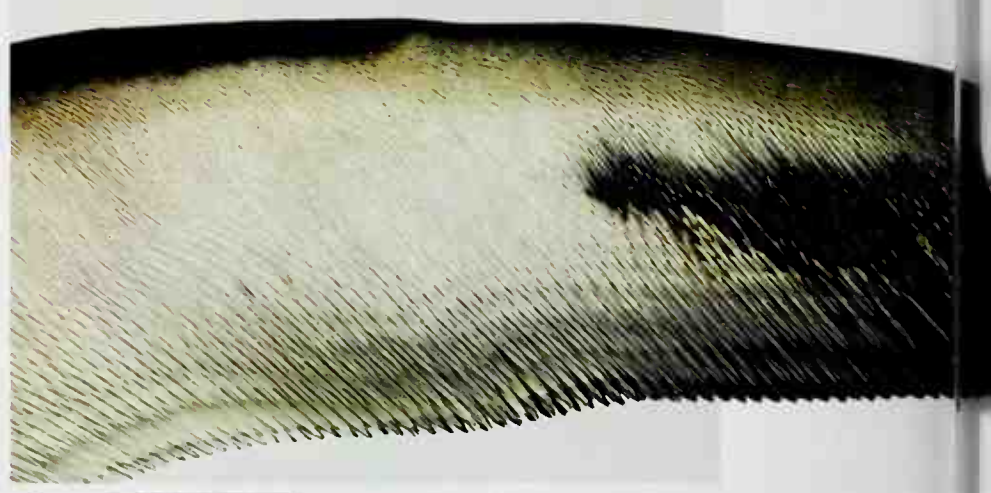


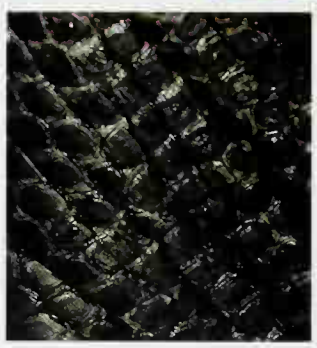
black upper mandible

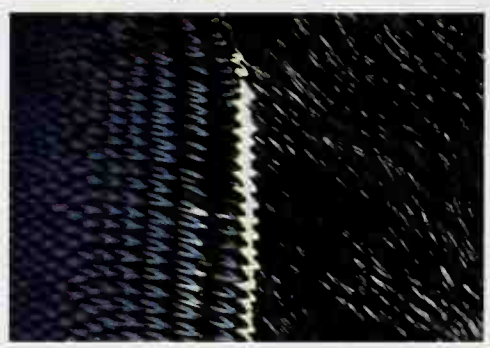
penguins drink seawater and excrete excess salt as brine through the nostrils

< SPINY TONGUE
A penguin's tongue is muscular and spiny: projections on the tongue surface called papillae have evolved into backward-facing barbs that help grip fish caught in dives.

∨ KEEN EYE
Penguins hunt by sight and have good underwater vision. Bioluminescent lanternfish, caught on nighttime dives, predominate in the diet of this species.







^ WING PROPULSION
Penguins are flightless birds, but they are propelled by feet and wings during dives. Their flipperlike wings effectively make them "fly" under water.

< DENSE FEATHERS
The feathers, arranged in an outer oily waterproof layer and inner downy insulating layers, are adapted for diving in cold water.

^ SCALY SKIN
Scales on the legs and feet are reminiscent of the reptilian roots of all birds; the dark skin may help spread heat to eggs and young.

^ EGG PROTECTOR
The single egg is incubated above the feet and beneath a fold of warm skin called a brood pouch. Once the chick has hatched, it uses the brood pouch for shelter.

WEBBED FOOT >
The kicking action of webbed feet helps propel the bird forward under water—and on land, when "tobogganing" over snow on its belly.

< FIRM TAIL
The short tail consists of stiffened feathers, used as a rudder under water. In smaller species, it is used as a prop on land.

COUNTERSHADED DIVER
Below its distinctive yellow markings, the king penguin has the tuxedo-style plumage pattern typical of penguins: white beneath and dark above. When diving, this pattern offers camouflage from aquatic predators. Seen from below, the pale belly is harder to see against the sunlit surface, and when seen from above, the bird's dark back blends in with the dark of the water below.

yellow markings are due to pigments called carotenoids, which are absent from some penguin species

yellow stripe on lower mandible

yellow breast

LOONS

These web-footed, fish-eating birds of Arctic waters have rear-set legs that limit their movement on land but provide excellent thrust for swimming.

Loons are the only family in the order Gaviiformes. Their name may originate from their haunting "lunatic" wailing cries uttered during the breeding season, or possibly from their ungainly motion when out of water. A loon's legs are set so far back on the body that the bird can only manage an awkward shuffle on land. In water, loons swim and dive with ease, possibly leading to their other name of diver. Their streamlined bodies and spearlike bills closely resemble those of penguins, which have similar habits—it is possible, although not certain, that these birds may share a common ancestor.

Although their pointed wings are relatively small for their body size, loons are fast fliers. To get themselves airborne, the larger species have to patter across open water; only the red-throated loon is able to take off from land. All species fly southward to overwinter.

SHARED PARENTING

Territorial male loons choose nest sites in vegetation on the shores of clear Arctic lakes, where both sexes incubate and tend the young. Young loon chicks ride on the backs of their parents, but they can swim and even dive soon after hatching. After breeding, loons lose their striking head and neck patterns, and their duller body plumage makes it more difficult to distinguish the different species.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	GAVIIFORMES
FAMILIES	1
SPECIES	5

Loons fly with their outstretched heads held slightly lower than the body, which gives them a hunchbacked appearance.

COMMON LOON
Gavia immer
F: Gaviidae

One of the largest loons, this bird breeds on lakes in subarctic regions of North America and Iceland. It overwinters on coasts farther south, including those around Britain.

27–36 in
69–91 cm

striped neck patch

black head and neck

30–36 in
76–91 cm

WHITE-BILLED LOON
Gavia adamsii
F: Gaviidae

A large species of Arctic waters, this white-billed bird can be distinguished from other loons by its yellowish white bill.

grayish head and neck

21–27 in
53–69 cm

23–29 in
58–74 cm

23–29 in
58–73 cm

RED-THROATED LOON
Gavia stellata
F: Gaviidae

The smallest loon, this bird breeds on small tundra pools in circumpolar regions and migrates south to Europe, China, and the southeastern USA to overwinter.

PACIFIC LOON
Gavia pacifica
F: Gaviidae

This species has similar striped plumage to that of the black-throated loon. Both species have white throats when not breeding.

BLACK-THROATED LOON
Gavia arctica
F: Gaviidae

Largely confined to Eurasia when breeding, this species sometimes reaches Alaska, but winters farther south, including the Pacific coast of North America.

white spots in summer

ALBATROSSES, PETRELS, AND SHEARWATERS

Long-winged albatrosses and their relatives spend much of their lives in the air, traveling great distances as they scan the surface of the oceans for fish.

These birds, the order Procellariiformes, are master aeronauts, rarely returning to land except to breed. Albatrosses, petrels, and shearwaters—called "tubenoses" on account of the tubular nasal protuberances on their bills—are globally widespread, ocean-going birds, but show the greatest diversity in the Southern Hemisphere.

Unusual for birds, they locate their sparsely scattered sea prey by smell. All but the smallest diving species in this group have elongated wings, and almost all have their webbed feet positioned so far back that some cannot easily walk. These birds deter predators by regurgitating a noxious oil that they produce in their stomachs and sometimes forcefully eject. This oil is also nutritious enough to feed their chicks.

SLOW REPRODUCTION

Tubenoses form pair bonds, sometimes for life, which in the larger species can be several decades. Many species breed in colonies on remote islands, often returning to the same site year after year. Smaller species nest in cavities and burrows. These birds have low breeding rates, but the parents invest heavily in rearing their young. Typically, tubenoses make only one breeding attempt per season and produce a single egg. Despite a lengthy incubation period, chicks are helpless upon hatching and mature very slowly.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PROCELLARIIFORMES
FAMILIES	4
SPECIES	133

Long-lived wandering albatrosses are monogamous. They reinforce their pair bonding with an elaborate courtship dance.

WANDERING ALBATROSS
Diomedea exulans
F: Diomedeidae
The largest of the giant Southern Ocean *Diomedea* albatrosses, this bird forms a life-long pair bond and produces a single young every two years.

dark wings turn white with age

mostly white body

pale pink bill

3½–4½ ft
1.1–1.4 m

LAYSAN ALBATROSS
Phoebastria immutabilis
F: Diomedeidae
Albatrosses from the northern Pacific include those that breed in the tropics, like this small species that nests on islands—including Hawaii—when breeding.

30–32 in
77–80 cm

27–29 in
68–74 cm

BLACK-FOOTED ALBATROSS
Phoebastria nigripes
F: Diomedeidae
Like other northern Pacific albatrosses, this small, dark species frequently interrupts its gliding flight with bursts of wing flapping.

18–20 in
45–50 cm

NORTHERN FULMAR
Fulmarus glacialis
F: Procellariidae
This gull-like petrel is common throughout the Northern Hemisphere. It nests on cliffs and can eject a foul-smelling stomach oil to repel predators.

white body, gray in parts

black "brow"

BLACK-BROWED ALBATROSS
Thalassarche melanophrys
F: Diomedeidae
This is one of several dark-backed albatrosses called mollymawks, from the Southern Hemisphere. It nests in dense colonies, producing one egg each year.

33–37 in
80–95 cm

»

» ALBATROSSES, PETRELS, AND SHEARWATERS

12 in
30 cm

AUDUBON'S SHEARWATER
Puffinus lherminieri
F: Procellariidae

This small bird breeds on tropical oceanic islands. Different populations are considered by some to be separate species.

sooty brown head

19 in
48 cm

PINK-FOOTED SHEARWATER
Puffinus creatopus
F: Procellariidae

A variable species existing in dark and light forms, this shearwater nests on islands off Chile. It migrates to the eastern Pacific during summer.

18–18½ in
45–47 cm

BULLER'S SHEARWATER
Puffinus bulleri
F: Procellariidae

This shearwater nests on islands off northern New Zealand but roams across the Pacific outside the breeding season.

18–22 in
45–56 cm

CORY'S SHEARWATER
Calonectris diomedea
F: Procellariidae

A large shearwater that glides with bowed wings, this species breeds in the Mediterranean region and overwinters in the Atlantic.

6½–8 in
17–20 cm

ANTARCTIC PRION
Pachyptila desolata
F: Procellariidae

Prions are small, gray Southern Ocean petrels that skim the sea to strain plankton with their flattened bills.

12 in
31 cm

dark zigzag pattern

JOUANIN'S PETREL
Bulweria fallax
F: Procellariidae

A tropical petrel of the northwestern Indian Ocean, this bird has a weaving flight. It is closely related to the gliding shearwaters.

14–16 in
36–41 cm

SNOW PETREL
Pagodroma nivea
F: Procellariidae

One of the few birds that breed on the Antarctic, this petrel breeds farther south than any other bird, even wandering to the South Pole.

16 in
41 cm

BLACK-CAPPED PETREL
Pterodroma hasitata
F: Procellariidae

Like many of the small, fast species known as gadfly petrels, this one has a tropical distribution. It breeds on islands of the West Indies.

17 in
43 cm

ANTARCTIC PETREL
Thalassoica antarctica
F: Procellariidae

A bird of sub-Antarctic waters, this large species dives for fish and squid. It breeds on islands around the Antarctic.

scattered dark feathers on white body

massive yellowish bill

15½–16 in
39–40 cm

CAPE PETREL
Daption capense
F: Procellariidae

One of several members of this family, mostly circumpolar in the southern hemisphere, the cape petrel breeds on islands around Antarctica and winters farther north.

34–39 in
86–99 cm

SOUTHERN GIANT PETREL
Macronectes giganteus
F: Procellariidae

This carrion-eating bird breeds in the South Atlantic. Unlike many other petrels, it has strong enough legs to walk well on land.

7½–8½ in
19–21 cm

BAND-RUMPED STORM PETREL
Oceanodroma castro
F: Hydrobatidae

Typical of Northern Hemisphere storm petrels, this tiny bird has a white-banded rump and forked tail. It is seen in both the Atlantic and Pacific.

GREBES

Birds of ponds and lakes, grebes characteristically swim low in the water and dive propeled by their feet. They feed on small aquatic animals.

Like many other diving birds, grebes have legs that are set far back on the body, making them clumsy on land but agile in water. The toes of their feet are lobed, providing good power strokes during diving, but minimizing drag in the water between strokes. The feet may be used for steering, too; in other diving birds, the tail is used for steering.

A grebe's tail is nothing more than a tuft of feathers. This serves more as a social signal than as a rudder, and is often cocked to expose white feathers beneath. The plumage is dense and well waterproofed by an oil gland. Uniquely in birds, the gland produces a secretion that is 50 per cent paraffin. Grebes have small wings and many species are often reluctant to fly, although northern species are migratory, traveling from inland habitats to the coast to overwinter.

Traditionally, grebes, the order Podicipediformes, are classified as close relatives of loons, penguins, and albatrosses. However, new research suggests that they may be related to flamingos.

RITUAL AND REPRODUCTION

In the breeding season, some grebes perform elaborate courtship rituals. They nest on floating mats of vegetation in freshwater habitats. The young are fully mobile upon hatching and can swim, but seek refuge on a parent's back for the first few weeks.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PODICIPEDIFORMES
FAMILIES	1
SPECIES	22

The courtship ritual of the great crested grebe culminates with both birds rising up from the water clutching a clump of weed.

9–11½ in
23–29 cm

LITTLE GREBE
Tachybaptus ruficollis
F: Podicipedidae

Found across the Old World, this bird is the most widespread of the small, dumpy grebes known as dabchicks. It has reddish neck when breeding.

9½–14 in
24–36 cm

WHITE-TUFTED GREBE
Rollandia rolland
F: Podicipedidae

A native of southern South America, this is a bird of open lakes with abundant water weeds. A related short-winged Andean species is flightless.

12–15 in
30–38 cm

PIED-BILLED GREBE
Podilymbus podiceps
F: Podicipedidae

This American bird is more stocky and has a stubbier bill than other grebes. Northern birds overwinter in the Caribbean, but tropical populations are sedentary.

16–20 in
40–50 cm

gray flanks

11–13½ in
28–34 cm

RED-NECKED GREBE
Podiceps grisegena
F: Podicipedidae

This species breeds in Eurasia and North America and overwinters farther south in coastal waters. Like other grebes, it migrates at night.

BLACK-NECKED GREBE
Podiceps nigricollis
F: Podicipedidae

Like other *Podiceps* grebes, this sharp-billed diver has a colorful head plumage when breeding. It is found across the Northern Hemisphere.

black head

22–30 in
55–75 cm

18–20 in
46–51 cm

10–11¼ in
25–29 cm

SILVERY GREBE
Podiceps occipitalis
F: Podicipedidae

This South American grebe is a colonial breeder, congregating on alkaline or salty lakes. It is found from the Andes to the Falkland Islands.

GREAT CRESTED GREBE
Podiceps cristatus
F: Podicipedidae

This Old World grebe is known for its courtship display. Like other grebes, both sexes are colorful.

WESTERN GREBE
Aechmophorus occidentalis
F: Podicipedidae

One of two similar western North American grebes, this species has a range from Canada to Mexico; northern populations winter off the Pacific coast.

dark gray back

white throat, breast, and belly

FLAMINGOS

These remarkable birds live on salty lagoons and alkaline lakes. Once classified with storks, flamingos are now thought to be related to grebes.

Extreme gregariousness defines flamingo life. These birds of the order Phoenicopteriformes congregate in huge flocks, sometimes numbering hundreds of thousands. These vast groups are so tightly packed that individual birds cannot easily take flight and must initially walk or run if disturbed. But the open habitat that flamingos favor, coupled with the vigilance of many birds, ensures that predators are easily seen.

The large flocks are necessary to stimulate breeding, and flamingo courtship involves group displays. Pairs build mud nests and territory is simply determined by how far a bird's neck will stretch from the nest. A few days after hatching, flamingo chicks gather together in large crèches. The parent birds feed their young with a liquid food called crop milk.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PHOENICOPTERIFORMES
FAMILIES	1
SPECIES	6

FILTER FEEDERS

Flamingos have a unique style of filter-feeding using a specially adapted bill. Holding its head upside-down, a flamingo strains planktonic algae and shrimps from the water through hairlike structures lining the bill. Pigments absorbed from the food give flamingos their characteristic pink color. There are few competitors for food—the organisms are taken from otherwise barren inland waters that are either very salty or caustic.

Some of the biggest flocks of flamingos are seen in the African Rift Valley, where lesser flamingos gather to feed.

CHILEAN FLAMINGO
Phoenicopterus chilensis
F: Phoenicopteridae
The most widespread flamingo in South America, the Chilean flamingo has a range from Peru to Tierra del Fuego, and is distinguished by gray legs with pink knees.
3¼–4¼ ft
1–1.3 m

CARIBBEAN FLAMINGO
Phoenicopterus ruber ruber
F: Phoenicopteridae
This Caribbean species differs from the greater flamingo in being somewhat smaller and having a pinker plumage.
4–4½ ft
1.2–1.4 m

GREATER FLAMINGO
Phoenicopterus ruber roseus
F: Phoenicopteridae
With a range spanning Africa, southern Europe, and Central Asia, this is the largest and most widespread of the flamingos.
3½–5 ft
1.1–1.5 m

ANDEAN FLAMINGO
Phoenicoparrus andinus
F: Phoenicopteridae
One of two flamingo species restricted to the higher altitudes of the Andes, this distinctively yellow-legged flamingo may wander nomadically between lakes for food.
3¼–3½ ft
1–1.1 m

LESSER FLAMINGO
Phoeniconaias minor
F: Phoenicopteridae
The smallest flamingo, this species from Africa and southern Asia occurs in huge numbers on highly alkaline lakes.
32–39 in
80–100 cm

STORKS, IBISES, AND HERONS

Most species in this group are wetland birds with long legs for walking through marshy or grassy habitats. They have long bills for snatching prey.

These birds, the Ciconiiformes, are hunters, predominantly of fishes and amphibians, but also sometimes of small mammals and insects. The majority frequent the margins of rivers and freshwater lakes and ponds, but some species of the stork family prefer drier habitats, such as pastureland.

Bill shape is one of the features that distinguish members of this order. The bills of herons and storks are usually straight and sharp-tipped but those of ibises and spoonbills are highly modified. Ibises have thin, curved bills that they use to probe in mud and soft earth; spoonbills sweep the distinctive, flattened tips of their bills in shallow water, snapping them shut when they detect prey. Herons and bitterns have modified vertebrae that allow the neck to form an S-shape, which is important for lightning-fast spearing of prey. The same skeletal modification enables these species to retract their necks in flight, unlike storks and ibises, which fly with their necks outstretched.

CLASS	CHORDATA
AVES	AVES
ORDER	CICONIIFORMES
FAMILIES	3
SPECIES	121

COLONIAL NESTING

Many birds of this group are gregarious when breeding, and their nesting colonies may include several species. Among the exceptions are the largely secretive and solitary bitterns. All species produce helpless young that must be reared in the nest for some weeks.

Storks typically nest in trees, but in western Europe white storks make good use of level platforms high on buildings.

3–4 ft
0.9–1.2 m

WOOD STORK
Mycteria americana
F: Ciconiidae

This North American bird belongs to a group of storks with ibislike bills. It submerges its open bill in shallow water, snapping it shut on moving prey.

SADDLE-BILL STORK
Ephippiorhynchus senegalensis
F: Ciconiidae

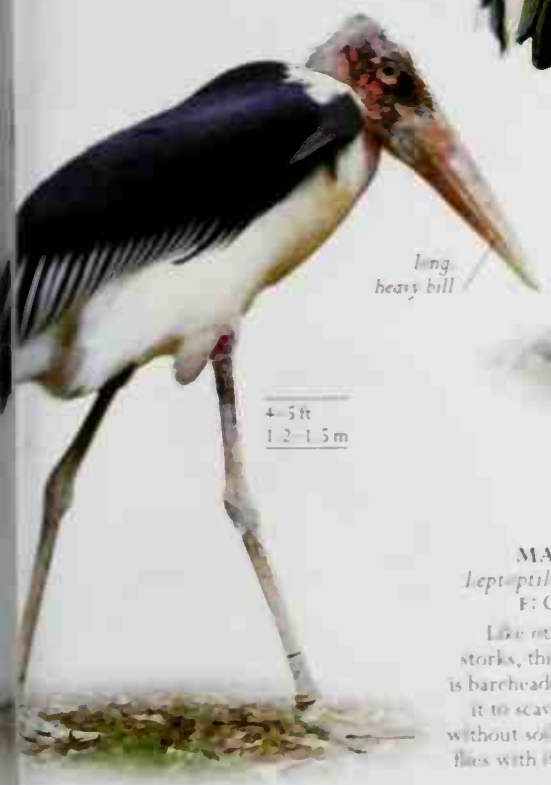
Related to the jabiru, this African stork has a slightly upturned bill with a yellow "saddle." It occurs in solitary pairs, even when nesting.

EUROPEAN WHITE STORK
Ciconia ciconia
F: Ciconiidae

Three *Ciconia* species breed outside the tropics. This European bird uses thermal updrafts on migration routes over land to winter in Africa.

WOOLLY NECKED STORK
Ciconia episcopus
F: Ciconiidae

The most widespread tropical stork, this bird occurs in both Africa and Asia. It prefers wetland habitats but may stray into pasture.



4–5 ft
1.2–1.5 m

MARABOU
Leptoptilos crumeniferus
F: Ciconiidae

Like other *Leptoptilos* storks, this African species is bareheaded, which enables it to scavenge in carrion without soiling its feathers. It flies with its head retracted.

JABIRU
Jabiru mycteria
F: Ciconiidae

A large American stork, the jabiru is the tallest flying bird in South America. It expands its featherless neck sac when excited.

AFRICAN OPENBILL
Anastomus lamelligerus
F: Ciconiidae

Small, tropical wetland storks, openbills use their distinctive bill to catch and manipulate molluscs before eating them. This species occurs in mainland Africa and Madagascar.

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» STORKS, IBISES, AND HERONS

greenish black cap
gray-green back
yellow legs and feet
16–22 in
40–55 cm

GREEN HERON
Butorides virescens
F: Ardeidae
A small heron of North American wetlands, the green heron may sometimes bait fishes with food at the water's edge.

23½–30 in
60–75 cm

AMERICAN BITTERN
Botaurus lentiginosus
F: Ardeidae
This is a typical solitary bittern. Its cryptic coloration and still, vertical posture help camouflage it in reed beds.

28–32 in
70–80 cm

EURASIAN BITTERN
Botaurus stellaris
F: Ardeidae
Like other bitterns, this species is more frequently heard than seen. It has a loud, booming call.

10½–15 in
27–38 cm

LITTLE BITTERN
Ixobrychus minutus
F: Ardeidae
Among the smallest of the heron-bittern family, this skulking Old World species clambers around reeds — sometimes freezing upright in typical bittern manner.

long, narrow crest
35–39 in
90–98 cm
32–39 in
80–100 cm
black tinge to white foreneck

GREY HERON
Ardea cinerea
F: Ardeidae
Familiar across Eurasia and Africa, the grey heron, like other larger herons, breeds in colonies. It builds stick nests in trees.

WHITE-NECKED HERON
Ardea pacifica
F: Ardeidae
This large heron of wet regions in Australia and New Guinea hunts for insects and small vertebrates in marshes and grassland.

32–39 in
80–100 cm

GREAT EGRET
Ardea alba
F: Ardeidae
Not a true egret but a large white heron, this marsh bird is widespread throughout much of the world.

22–28 in
55–70 cm

YELLOW-CROWNED NIGHT HERON
Nyctanassa violacea
F: Ardeidae
This American night heron is sedentary in tropical regions, but in the colder parts of its range, it migrates southward during winter.

19–21 in
48–53 cm

CATTLE EGRET
Bubulcus ibis
F: Ardeidae
Actually a small white heron, this globally widespread species forages on grassland and often follows livestock to catch disturbed prey.

23–25 in
58–63 cm

22–22½ in
55–57 cm

23½–28 in
60–70 cm

22–26 in
55–65 cm

LITTLE BLUE HERON
Egretta caerulea
F: Ardeidae
This American species belongs to the egret group. The purplish head and neck turn gray-blue outside the breeding season.

22–26 in
55–65 cm

LITTLE EGRET
Egretta garzetta
F: Ardeidae
Found from Europe to Australia, this species has a distinct black bill and legs, and the more widespread race has yellow feet.

WHITE-FACED HERON
Egretta novaehollandiae
F: Ardeidae
A member of the egret group from Indonesia, Australia, and New Zealand, this species has a varied diet that includes insects and frogs.

TRICOLORED HERON
Egretta tricolor
F: Ardeidae
This is an inhabitant of American swamps, where, like related species, it uses its daggerlike bill to spear small animals.

WESTERN REEF HERON
Egretta gularis
F: Ardeidae
A coastal species from Africa and India, this heron has white and dark gray color forms, as well as intermediate forms.

18–20 in
45–50 cm

BOAT-BILLED HERON
Cochlearius cochlearius
F: Ardeidae
This heron has a broad bill, adapted for scooping and stabbing animal prey. It inhabits mangrove swamps of Central and South America.

BLACK-CROWNED NIGHT HERON
Nycticorax nycticorax
F: Ardeidae

Night herons have good night vision. Found in most warm regions except Australia, this is the most widespread species.

23–26 in
58–65 cm

AUSTRALIAN IBIS
Threskiornis molucca
F: Threskiornithidae

This is a common species throughout Australia. It often invades urban areas, where it is sometimes considered a pest.

bare head and neck

26–30 in
65–75 cm

27–30 in
69–76 cm

INDIAN POND HERON
Ardeola grayii
F: Ardeidae

Common in southern Asia, this heron stalks aquatic prey, but it may also flush fishes by flying low over water.

16½–18 in
42–45 cm

SACRED IBIS
Threskiornis aethiopicus
F: Threskiornithidae

This is a common bird of the wetlands and grasslands of Africa and Madagascar. It has been introduced into America and Europe.

black wing plumes

black-tipped bill

27–32 in
68–82 cm

23–30 in
59–76 cm

30–35 in
76–89 cm

HADADA IBIS
Bostrychia hagedash
F: Threskiornithidae

A common African species found in grasslands, forests, parks, and gardens, the hadada ibis is named after its distinctive flight call.

30 in
75–77 cm

STRAW-NECKED IBIS
Threskiornis spinicollis
F: Threskiornithidae

So called because of the strawlike feathers at the base of its neck, this nomadic ibis occurs in New Guinea and Australia.

neck plumes when breeding

gray body

22–26 in
55–65 cm

REDDISH EGRET
Egretta rufescens
F: Ardeidae

This American species has white and reddish gray color forms. When fishing, it sometimes holds out its wings to reduce sun glare.

BLACK-FACED IBIS
Theristicus melanopis
F: Threskiornithidae

Found in South America, this species occurs in temperate grassland habitat from the Andes to Patagonia.

GLOSSY IBIS
Plegadis falcinellus
F: Threskiornithidae

Found throughout warm parts of the world, this is the most widespread ibis species. Its tree-nesting colonies may be accompanied by herons.

pinkish red patch on wing

pink breast tuft when breeding

black wing tip

22–24 in
56–61 cm

35–36 in
90–92 cm

28–33 in
71–86 cm

gray legs

32–35 in
80–90 cm

SCARLET IBIS
Eudocimus ruber
F: Threskiornithidae

The national bird of Trinidad, the scarlet ibis occurs in tropical America and acquires its scarlet pigment from eating crustaceans.

AFRICAN SPOONBILL
Platalea alba
F: Threskiornithidae

The only spoonbill confined to wetlands of Africa, this species is characterized by its red face and legs.

EURASIAN SPOONBILL
Platalea leucorodia
F: Threskiornithidae

This species breeds in Eurasia and overwinters in Africa. Unlike the African spoonbill, it does not nest with herons and storks.

ROSEATE SPOONBILL
Ajaia ajaja
F: Threskiornithidae

Like other spoonbills, this distinctive American species feeds on small aquatic animals by swinging its bill from side to side in water.

PELICANS AND RELATIVES

Long-winged, web-footed, fish-eating birds are typical of this order. Most hunt either by plunge-diving or by skimming the water surface.

The common characteristics of this group include reduced nostrils, a particularly important feature in plunge-diving cormorants, shags, gannets, and boobies. Birds of this order, Pelecaniformes, also share the same foot structure, with webbing that spans all four forward-pointing toes. Many of these birds incubate their eggs by holding them on their feet. Frigatebirds, which have reduced webbing between their toes, use a featherless breast area called a brood patch, rather than feet, to keep their eggs warm. Remarkably, cormorants, shags, and anhingas lack good waterproofing, and after diving spread their wings to dry. Frigatebirds are also poorly waterproofed, they avoid landing in water and skim prey from the surface.

Although awkward and weak-footed on land, frigatebirds and the plunge-diving tropicbirds are superb fliers. Frigatebirds can stay aloft night and day, traveling long distances to feed.

THROAT POUCHES

Almost all these birds have throat pouches, which serve a variety of purposes. Pelicans use their capacious, highly flexible pouch to scoop large catches of fish. Cormorants and anhingas stretch their pouches in courtship display, something male frigatebirds take to an extreme with their hugely inflated bright red throat sacs.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PELECANIFORMES
FAMILIES	8
SPECIES	67

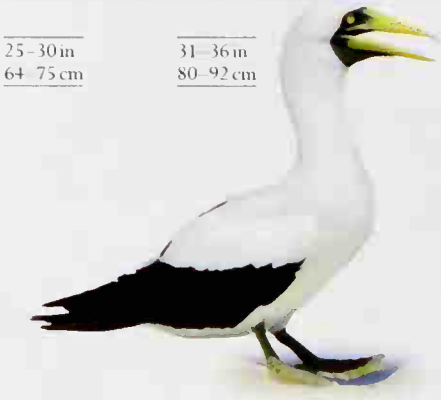
This pelican chick reaches deep into its parent's throat to feed on regurgitated, partly digested fish.

SHOEBILL
Balaeniceps rex
F: Balaenicipitidae

Restricted to swamps from Sudan to Zambia, this wading bird uses its huge bill to scoop vertebrate prey from muddy waters.

BROWN BOOBY
Sula leucogaster
F: Sulidae

Like other boobies, this widespread species—the only one with predominantly dark plumage—nests in colonies on tropical coasts, often on islands.



MASKED BOOBY
Sula dactylatra
F: Sulidae

This is the largest of the tropical boobies, with a black and white plumage and long, yellow bill. It most closely resembles the related cold-water gannets.

BLUE-FOOTED BOOBY
Sula nebouxii
F: Sulidae

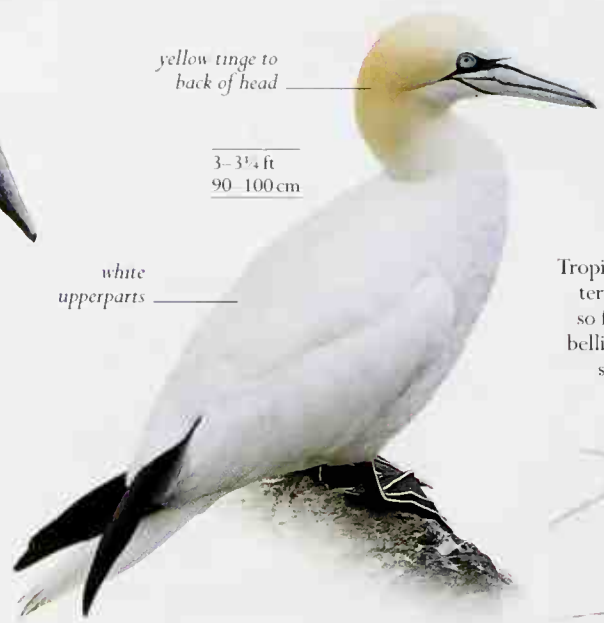
Found on rocky coasts from California to Peru and the Galapagos Islands, this booby flaunts its blue feet as part of its courtship display.

MAGNIFICENT FRIGATEBIRD
Fregata magnificens
F: Fregatidae

infrequent feeding opportunities and long hours in flight cause frigatebirds, such as this American species, to have a low breeding rate and the longest period of parental care of any bird.

HAMMERKOP
Scopus umbretta
F: Scopidae

This African wetland bird builds huge, heavy-walled nests using sticks and mud to protect its young, who are often left for long periods.



NORTHERN GANNET
Morus bassanus
F: Sulidae

The three similar species of cold-water gannets breed in large colonies on rocky coasts. This one is a native of the North Atlantic.

WHITE-TAILED TROPICBIRD
Phaethon lepturus
F: Phaethontidae

Tropicbirds are streamer-tailed, tern-like seabirds with feet so feeble that they use their bellies to shuffle on land. This species frequents most tropical coastlines.

RED-BILLED TROPICBIRD
Phaethon aethereus
F: Phaethontidae

Found from the eastern Pacific to the Atlantic, this typical, hole-nesting tropicbird rears a single, slow-growing chick, an adaptation to scattered ocean food resources.

ANHINGA
Anhinga anhinga
F: Anhingidae

This American species has a long, cormorant-like neck and a straight bill for spearing fish. These birds are also called snake birds or darters.

30–37 in
75–95 cm

snakelike neck

spearlike bill

28–35 in
70–90 cm

DOUBLE-CRESTED CORMORANT
Phalacrocorax auritus
F: Phalacrocoracidae

A typical, medium-sized cormorant, this American species is named for its two white head tufts that develop during breeding.

28 in
71 cm

RED-FACED SHAG
Phalacrocorax urile
F: Phalacrocoracidae

A deep-diving seabird found from Japan to the Bering Sea, this species belongs to a group of North Pacific cormorants that are highly adapted to the marine environment.

32–39 in
80–100 cm

GREAT CORMORANT
Phalacrocorax carbo
F: Phalacrocoracidae

This cormorant is widespread in temperate and tropical regions. It usually hunts in shallow waters, but can dive up to 100 ft (30 m).

20–22 in
50–55 cm

LITTLE PIED CORMORANT
Phalacrocorax melanoleucos
F: Phalacrocoracidae

This is an Australasian member of a group of primitive, short-billed "micro-cormorants" that are largely associated with freshwater or estuarine habitats.

26–32 in
65–80 cm

EUROPEAN SHAG
Phalacrocorax aristotelis
F: Phalacrocoracidae

The European shag develops a frontal crest when breeding. It is a common seabird of northeast Atlantic rocky coasts, where it nests on ledges.

3–3½ ft
90–100 cm

FLIGHTLESS CORMORANT
Phalacrocorax harrisi
F: Phalacrocoracidae

The only living flightless cormorant, this bird inhabits the Galapagos Islands. It evolved from an American group that includes the double-crested cormorant.

30 in
75–76 cm

RED-LEGGED CORMORANT
Phalacrocorax gaimardi
F: Phalacrocoracidae

An unusually patterned coastal cormorant of temperate South America, this species resembles certain sub-Antarctic shags, but apparently has no close relatives.

orange throat pouch

18–22 in
45–55 cm

4½–5 ft
1.3–1.5 m

all-white plumage

PYGMY CORMORANT
Phalacrocorax pygmeus
F: Phalacrocoracidae

The smallest cormorant, this species frequents reed bed habitats on fresh or brackish water from central Europe to Central Asia.

SPOT-BILLED PELICAN
Pelecanus philippensis
F: Pelecanidae

A species from southern Asia, the spot-billed pelican, like most other pelicans, fishes by scooping prey while swimming on the water surface.

red-tipped bill

3½–4½ ft
1–1.4 m

BROWN PELICAN
Pelecanus occidentalis
F: Pelecanidae

This gray and brown pelican from the southern USA to South America is a coastal-breeding species and, unlike other pelicans, plunge-dives for fish.

4½–5½ ft
1.3–1.6 m

AMERICAN WHITE PELICAN
Pelecanus erythrorhynchos
F: Pelecanidae

This pelican breeds on inland lakes of N. America and overwinters on the coasts. In the breeding season, it develops a flat "horn" on its bill.

BIRDS OF PREY

The largest and most important group of day-flying hunters, almost all the birds in this order are exclusively meat-eaters. In some habitats they are the top predators.

Even the smallest members of the order Falconiformes, such as the tiny pygmy falcon, are killers, capable of dispatching birds as big as themselves. Others such as the harpy eagle and Philippine eagle of tropical rain forests, are so powerful they can tackle and kill large monkeys or even small deer.

Birds of prey typically have keen vision and hunt by sight. Only one species, the turkey vulture, detects food sources by smell. Birds of this order have strong clawed feet with opposable hind talons for gripping food and a sharply hooked bill for tearing flesh. Feeding behavior varies from group to group. Large eagles can kill their prey with their talons. Falcons typically deliver a killing bite to the neck of their victim, severing the spinal cord.

The birds of this order are strong winged and some species fly very high in the sky. The largest birds of prey, including eagles, buteos, and vultures, conserve energy by soaring.

SCAVENGERS

The Old World vultures and the American condors follow a scavenging lifestyle. These huge birds have weaker bills for tearing carrion. The bare-headed American vultures may be more closely related to storks than to other birds of prey, but the issue is unresolved.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	FALCONIFORMES
FAMILIES	3
SPECIES	319

DEBATE

FALCON CONTROVERSY

DNA testing indicates that falcons may not be birds of prey but members of a different order, closer to the parrots. Falcons possibly evolved to resemble hawks because of a similar lifestyle (convergent evolution), and not because they have a common ancestor.

25–32 in
64–81 cm

22–26 in
56–66 cm

white streaks on massive wings

TURKEY-VULTURE
Cathartes aura
F: Cathartidae

Unusual for birds, this widespread American vulture locates rotting carcasses by smell. It often nests in dark recesses, such as under large rocks or stumps.

BLACK VULTURE
Coragyps atratus
F: Cathartidae

More gregarious than the related turkey-vulture, the black vulture is an opportunistic scavenger found from the central USA to Chile.

26–32 in
67–81 cm

contrasting black and white wings

9–12 in
23–30 cm

ANDEAN CONDOR
Vultur gryphus
F: Cathartidae

3¾–4½ ft
1–1.4 m

South America's largest flying land bird, this species soars on updraughts in the Andes, locating carrion by sight or by following other scavengers, such as turkey-vultures.

KING VULTURE
Sarcoramphus papa
F: Cathartidae

This large bird soars high above forests of tropical America looking for carrion. It is distinguished by its colorful head and fleshy bill wattle.

BAT FALCON
Falco rufigularis
F: Falconidae

This swift-flying American bird hunts birds, bats, and large insects at twilight. It is found from Mexico to Argentina.

AMERICAN KESTREL
Falco sparverius
F: Falconidae

Kestrels are small falcons that habitually hover when hunting. This species is distributed throughout the Americas, including the Caribbean islands.

8–12 in
20–31 cm

MERLIN
Falco columbarius
F: Falconidae
A nimble predator with a dashing flight, this falcon captures birds in midair over hills and moorland across the Northern Hemisphere.

9½–13 in
24–33 cm

AMUR FALCON
Falco amurensis
F: Falconidae
Unusual for falcons, this raptor habitually gathers in flocks. It breeds in marshy woodland across Siberia and China and migrates to southern Africa to overwinter.

10–12 in
26–30 cm

dark "moustache"

PEREGRINE FALCON
Falco peregrinus
F: Falconidae
As the fastest bird of prey, this falcon dives steeply on prey in midair. It is found throughout the world in open country, including tundra and semidesert.

14½–23 in
36–58 cm

slate-gray upperparts

12½–15½ in
32–39 cm

COMMON KESTREL
Falco tinnunculus
F: Falconidae
Like other kestrels, this species of open country across Eurasia and Asia uses updrafts to maintain its hovering as it scans the ground for prey.

7–8½ in
18–21 cm

AFRICAN PYGMY FALCON
Polihierax semitorquatus
F: Falconidae
This African bird dives for insects and lizards on ground. It breeds in the nests of weaver birds and may raise a brood cooperatively with others.

white neck ruff

yellow feet

19–21 in
48–53 cm

MOUNTAIN CARACARA
Phalcoboenus megalopterus
F: Falconidae
Relatives of falcons, caracaras are more sluggish and longer legged. Like other caracaras, this species of the high Andes is a scavenger, but it also hunts small animals.

21–24 in
53–62 cm

STRIATED CARACARA
Phalcoboenus australis
F: Falconidae
The tendency of this fearless caracara to attack newborn lambs has led to persecution in its native Falkland Islands.

fleshy comb

16–18 in
40–46 cm

YELLOW-HEADED CARACARA
Milvago chimachima
F: Falconidae
A hawklike scavenger that also eats oil palm fruit, this bird of southern South America frequents savanna and forest edges.

black crown and crest

yellowish red facial skin

19–23 in
49–58 cm

elongated central tail feathers

head plumes

20½–26 in
52–66 cm

OSPREY
Pandion haliaetus
F: Accipitridae
Found almost worldwide, the fish-eating osprey plunges for its prey and has a reversible outer toe for a better grip on its slippery catch.

4½–5 ft
1.4–1.5 m

long legs

SECRETARY BIRD
Sagittarius serpentarius
F: Accipitridae
One of the few raptors to hunt on ground, this long-legged bird of African savannas chases small animals, often stamping to disable them.

CRESTED CARACARA
Caracara cheriway
F: Falconidae
This common species of caracara is found in open country, from the southern USA to northern South America. It nests in trees or on the ground.

»

» BIRDS OF PREY

white head and neck
chestnut upperparts
17–20 in
43–51 cm

BRAHMINY KITE
Haliastur indus
F: Accipitridae
With a range from India to Australasia, this riverside and coastal scavenger also hunts for live prey such as fishes and small mammals.

20–25 in
50–64 cm

SWALLOW-TAILED KITE
Elanoides forficatus
F: Accipitridae
This insect-eating bird of prey is a graceful and agile flier. It breeds in the southeastern USA and Central America, and winters in South America.

12½–15 in
32–38 cm

WHITE-TAILED KITE
Elanus leucurus
F: Accipitridae
Typical of its genus, this sharp-browed kite habitually hovers when hunting. It occurs from the USA to South America, outside the Amazon basin.

20½–23½ in
52–60 cm

EUROPEAN HONEY BUZZARD
Pernis apivorus
F: Accipitridae
Belonging to a group of tropical raptors that eat bee and wasp larvae, this species breeds in Eurasia and overwinters in Africa.

pale head
red-brown tail
feathered legs

GOLDEN EAGLE
Aquila chrysaetos
F: Accipitridae
A graceful soaring bird, this large, long-tailed eagle occurs in open country across the Northern Hemisphere. It frequents forests in some regions.

23½–39 in
60–100 cm

28–33 in
70–83 cm

EASTERN IMPERIAL EAGLE
Aquila heliaca
F: Accipitridae
True eagles, including those of the *Aquila* genus, such as this Eurasian species, are described as "booted" because of their fully feathered legs.

24–30 in
61–75 cm

CHANGEABLE HAWK-EAGLE
Spizaetus cirrhatus
F: Accipitridae
Often crested, Asian hawk eagles are forest raptors. This variable species has dark and pale forms and is found from the Himalayas to Indonesia.

28–38 in
71–96 cm

BALD EAGLE
Haliaeetus leucocephalus
F: Accipitridae
This North American sea eagle and USA national symbol, captures or scavenges fish, sometimes hunting cooperatively. It breeds in woodland near water.

28–35 in
70–90 cm

WHITE-BELLIED SEA EAGLE
Haliaeetus leucogaster
F: Accipitridae
With a distribution from India to Australasia along lakes and rivers, like other large eagles, this fishing raptor builds huge stick nests.

22–28 in
55–72 cm

BONELLI'S EAGLE
Hieraaetus fasciatus
F: Accipitridae
A woodland- and mountain-dwelling species, this long-winged buzzardlike eagle has a range that extends from southern Eurasia to North Africa.

22–26 in
55–65 cm

dark brown flight feathers

AFRICAN HAWK EAGLE
Hieraaetus spilogaster
F: Accipitridae
A small raptor from suh-Saharan Africa, this hawk eagle hunts in wooded savanna and hilly country.

35–39 in
90–98 cm

AFRICAN WHITE-BACKED VULTURE
Gyps africanus
F: Accipitridae

One of the most common vultures of the sub-Saharan savanna, this species gathers in large numbers near carcasses. These birds are seen in towns and villages.

34–38 in
85–97 cm

3½–4½ ft
1–1.3 m

BEARDED VULTURE
Gypaetus barbatus
F: Accipitridae

Native to the mountains of Africa and Eurasia, this diamond-tailed, solitary vulture subsists largely on marrow obtained by dropping bones on rocks to split them open.

3½–4 ft
1–1.2 m

LAPPET-FACED VULTURE
Torgos tracheliotus
F: Accipitridae

Like the related *Gyps* vultures, this carrion eater of arid Africa has a long neck and a bare head to prevent carcasses from soiling its plumage.

bulbous bill

EURASIAN GRIFFON
Gyps fulvus
F: Accipitridae

This vulture occurs in mountainous regions of southwestern Eurasia and northeastern Africa. It breeds and roosts among rocks and on ledges.

neck ruff turns white with age

3–3½ ft
0.9–1.1 m

RÜPPELL'S VULTURE
Gyps rueppelli
F: Accipitridae

An African relative of the Eurasian griffon, this darker species inhabits arid areas. It has been recorded as flying at higher altitudes than any other bird.

23½ in
60 cm

28–34 in
72–85 cm

23–28 in
60–70 cm

PALM-NUT VULTURE
Gypohierax angolensis
F: Accipitridae

Unusual for a vulture, this African species has a largely vegetarian diet, consisting of oil palm fruit. However, it also feeds on fishes and carrion.

WHITE-HEADED VULTURE
Trigonoceps occipitalis
F: Accipitridae

Found in northern, eastern, and southern Africa, this vulture is often seen in pairs, and is usually outnumbered by other vulture species when feeding on carcasses.

EGYPTIAN VULTURE
Neophron percnopterus
F: Accipitridae

A relative of the palm-nut vulture, this bird of southern Eurasia and Africa routinely uses rocks to crack open ostrich eggs.

dark brown to white coloration

15–17 in
38–43 cm

20–26 in
50–65 cm

20–22½ in
51–57 cm

WHITE-EYED BUZZARD
Butastur teesa
F: Accipitridae

This small buzzard-hawk from southern Asia is more terrestrial than related species, hunting small animals and insects on the ground.

LONG-LEGGED BUZZARD
Buteo rufinus
F: Accipitridae

This buzzard of semideserts and mountains breeds in central Europe and Central Asia, with some populations migrating to North Africa in winter.

EURASIAN BUZZARD
Buteo buteo
F: Accipitridae

A common raptor, this species has light and dark color forms. Its northern populations overwinter in tropical Africa and Asia.

»

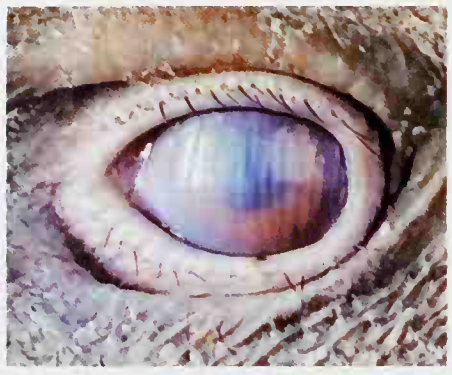
RÜPPELL'S VULTURE

Gyps rueppellii

One of the iconic scavengers of the African plains, from Senegal east to Sudan and Tanzania, Rüppell's vulture is able to fly at great heights in its search for food because its blood is specially adapted to capture oxygen in the thin air. This vulture patrols dry mountainous terrain, leaving its cliff-top roost sites in early morning to rise on updrafts instead of thermals. It uses acute vision to find carcasses and will wait patiently—days, if necessary—for predators to leave a kill. Like most vultures, it eats soft, rotting flesh and offal. However, its longer neck allows it to reach deeper into corpses than many of its competitors, gorging its fill until, with some difficulty, it returns to the skies.

SIZE 34–38 in (85–97 cm)
HABITAT Gorges in dry, open country
DISTRIBUTION North and East Africa
DIET Carrion

> THIRD EYELID
A typical feature of birds, this membrane cleans the surface of the eye, and may help protect against flying debris during frenzied feeding.



v WHITE COLLAR
White fluffy feathers encircling the base of the neck form a ruff. This may be discolored with dust and blood from carcasses.

< SCALLOPING
This vulture's dark wing feathers are broadly tipped with lighter marking, giving the bird a scalloped appearance at a distance.

< PLUMAGE
Beneath the patterned feathers that mark the contours of the body are fluffy down feathers that trap body heat—vital at high altitude.

^ WING
Long, broad wings help the vulture soar or glide, saving energy. Takeoff can be a struggle after a heavy meal.

< LEG
Although the bird's thigh is feathered, its strong legs are bare and so remain relatively clean when the bird is feeding on carcasses.

> A HEAD FOR GORE
Although the sparse down of the vulture's head and neck is frequently blood-stained, a fully feathered head would get clogged with sticky debris as the bird reached deep inside the carcasses of large mammals to feed. The vulture's hooked bill is used to tear semi rotten flesh, and is long enough to probe carcasses.

< FOOT
Because vultures use their feet for walking rather than killing, they lack the big talons that are typical of predatory birds of prey.

pinkish gray skin of head and neck has a light coating of down

18–21 in
46–53 cm

RED-BACKED HAWK
Buteo polyosoma
F: Accipitridae

A South American hawk of mountain slopes, sometimes above the treeline, this species habitually hovers. It has gray and brown color phases.

18–22 in
45–56 cm

RED-TAILED HAWK
Buteo jamaicensis
F: Accipitridae

The most common hawk in North America, it has an aerial courtship display in which pairs often clasp feet and spiral downward.

17–24 in
43–61 cm

RED-SHOULDERED HAWK
Buteo lineatus
F: Accipitridae

Among the most vocal of American hawks, this species from eastern and southern North America is found in woodland near water.

19–22 in
48–56 cm

SWAINSON'S HAWK
Buteo swainsoni
F: Accipitridae

Huge flocks of the Swainson's hawk migrate from Canada to Argentina, a distance that—among raptors—is exceeded only by the peregrine.

18–20 in
46–51 cm

BLACK-COLLARED HAWK
Busarellus nigricollis
F: Accipitridae

A relative of the snail kite, this species occurs in Central and South American wetlands, where it fishes by dropping feet first into floating vegetation.

13½–14½ in
34–37 cm

MISSISSIPPI KITE
Ictinia mississippiensis
F: Accipitridae

Related to hawks and buzzards, this North American raptor inhabits open woodland and is a colonial nester. It overwinters in South America.

21½–24 in
54–61 cm

SAVANNA HAWK
Buteogallus meridionalis
F: Accipitridae

This South American hawk hunts on the ground, sometimes following forest and grass fires to catch small animals that have been disturbed.

23½–26 in
60–66 cm

RED KITE
Milvus milvus
F: Accipitridae

Like other *Milvus* kites, this species from Europe and the Middle East is slightly weak footed, but accomplished at soaring. It frequently feeds on carrion.

narrow, strongly hooked bill

14–16 in
36–40 cm

red feet

SNAIL KITE
Rostrhamus sociabilis
F: Accipitridae

This bird from Florida and Central and South American marshes has a strongly curved bill, adapted for feeding on aquatic snails.

18–23 in
46–59 cm

HARRIS'S HAWK
Parabuteo unicinctus
F: Accipitridae

Found from California into S. America, this co-operative hunter works in small groups to flush out prey.

22–23½ in
55–60 cm

deeply forked tail

BLACK KITE
Milvus migrans
F: Accipitridae

Found in open country across Eurasia, Africa, and Australasia, the black kite has a varied diet that includes live fish and small mammals, carrion, and sometimes human refuse.

18–22 in
46–56 cm

WHITE HAWK
Leucopternis albicollis
F: Accipitridae

This forest hawk of Central and South America hunts for reptiles, especially snakes. It has been described as lethargic and easily approached.

23½–26 in
60–66 cm

AFRICAN HARRIER-HAWK
Polyboroides typus
F: Accipitridae

This raptor from sub-Saharan Africa eats oil-palm fruit and hunts small vertebrates. Its flexible "double-jointed" legs help it take prey from tree-holes.

17–22 in
43–56 cm

DARK CHANTING GOSHAWK
Melierax metabates
F: Accipitridae

An African hawk of dry, open country, this bird resembles a harrier when in flight. It has a musical piping call.

17½–20½ in
44–52 cm

NORTHERN HARRIER
Circus cyaneus
F: Accipitridae

Harriers are characterized by a narrow tail, narrow, pointed wings, and long legs. This species is widespread in the Northern Hemisphere.

17–18½ in
43–47 cm

MONTAGU'S HARRIER
Circus pygargus
F: Accipitridae

Eurasian harriers, such as the Montagu's harrier, migrate to Africa and southern Asia. This species inhabits grassland and reed beds.

19–22 in
48–56 cm

WESTERN MARSH HARRIER
Circus aeruginosus
F: Accipitridae

The males of this species are brown, like the females, with gray on their wings and tail. Males of other harrier species are all gray.

12–14½ in
30–37 cm

LIZARD BUZZARD
Kaupifalco monogrammicus
F: Accipitridae

A native of the African savanna, this bird mostly preys on large insects, such as grasshoppers, but also eats small vertebrates.

10–14 in
25–35 cm

SHIKRA
Accipiter badius
F: Accipitridae

A typical *Accipiter* hawk with a long tail and short wings, the Old World shikra has a dashing flight for catching small animals, including birds.

19–24 in
48–62 cm

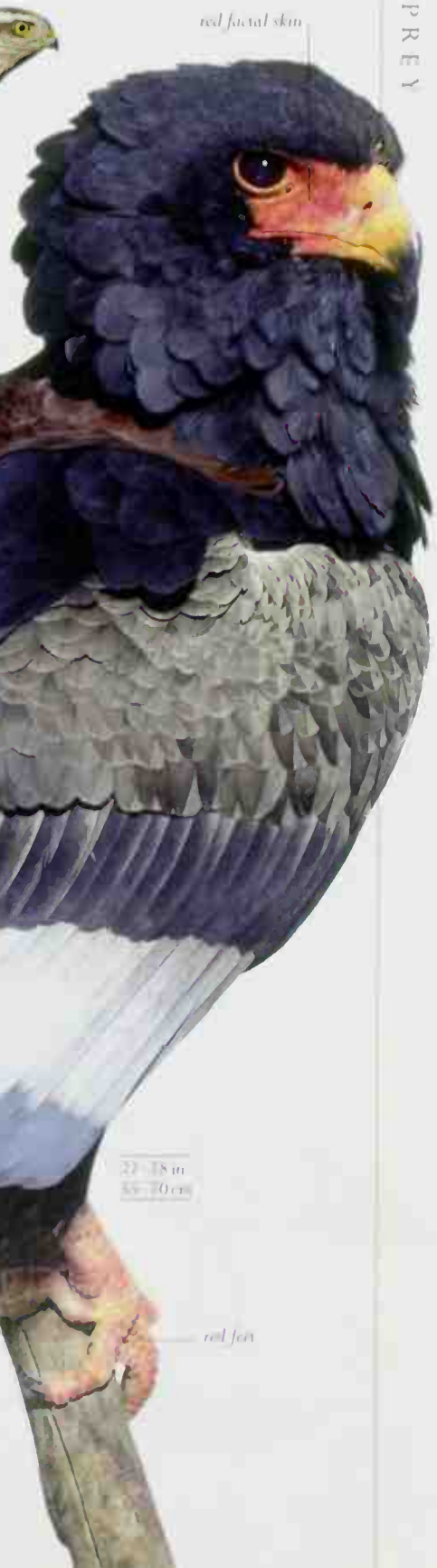
NORTHERN GOSHAWK
Accipiter gentilis
F: Accipitridae

This large hawk from North America and Eurasia is capable of crashing through dense forest to catch squirrels and grouse.

11–16 in
28–40 cm

EURASIAN SPARROWHAWK
Accipiter nisus
F: Accipitridae

One of nearly 50 species of *Accipiter* hawks, this hunter of small birds is found in woodland habitats from Europe to Japan.



22–38 in
55–70 cm

BATELEUR
Terathopius ecaudatus
F: Accipitridae

This African savanna bird is the only snake eagle that regularly eats carrion. *Bateleur* means "acrobat" in French, a reference to this bird's acrobatic flight.

BLACK-BREASTED SNAKE EAGLE
Circaetus pectoralis
F: Accipitridae

A bird of African grasslands, this eagle feeds on lizards and small mammals as well as snakes.

25–27 in
63–68 cm

BROWN SNAKE EAGLE
Circaetus cinereus
F: Accipitridae

Snake eagles typically watch for prey from exposed perches. This African species may hover before plunging to kill snakes on the ground.

28–30 in
71–76 cm

24–26 in
62–67 cm

SHORT-TOED EAGLE
Circaetus gallicus
F: Accipitridae

A Eurasian member of a group of snake-eating eagles, this species occurs on rocky hillsides and coastal plains.

22–30 in
55–74 cm

CRESTED SERPENT EAGLE
Spilornis cheela
F: Accipitridae

Belonging to a group of Asian snake eagles, this species inhabits a range from India to the Philippines, and is often found near freshwater.

CRANES AND RAILS

From graceful dancing cranes to small skulking rails, this order contains a wide variety of ground-dwelling birds of both dry and wetland habitats.

Mostly long-legged, long-billed birds, members of the order Gruiformes are behaviourally very diverse. It is possible that many of the groups traditionally included here may belong in another order. The sunbittern and kagu are almost certainly not allied to cranes and rails, but their biological relationships are still uncertain.

Cranes and their relatives spend most of their time on the ground and their foot structure is adapted accordingly: without the need to perch, their hind toe is reduced or absent. The most aquatic members of the order, such as the finfoots and coots, have lobed, not webbed, feet. Nearly three-quarters of species in the group belong to the rail family. Many rails live in wetlands and have flat-sided bodies to enable them to move easily through thick reed beds.

The much larger bustards and cranes live in more open country, where they can show off their elaborate courtship displays. Bustards prefer dry, sometimes semidesert habitats.

FLIGHTLESS SPECIES

Many species in this group have colonized oceanic islands, where a few have evolved into flightless forms in habitats that were originally predator-free. Rats and other introduced animals now pose a threat to such species.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	GRUIFORMES
FAMILIES	11
SPECIES	228

Red-crowned cranes, like other crane species, engage in elaborate dances to attract mates or reinforce pair bonding.

GREAT BUSTARD
Otis tarda
F: Otidae

Male bustards are bigger than females, especially so in this species of Eurasian steppes. Adult birds take six years to mature and develop plumes.

rufous breast band

28–43 in
70–110 cm

16–18 in
40–45 cm

22–26 in
55–65 cm

LITTLE BUSTARD
Tetrax tetrax
F: Otidae

This diminutive bustard breeds in open country across Eurasia and migrates southward in winter. In flight, it resembles a shelduck.

HOUBARA BUSTARD
Chlamydotis undulata
F: Otidae

A native of arid country, this bird is found in open plains and barren desert areas of northern Africa and the Canary Islands.

3¼–4½ ft
1–1.4 m

orange-brown wings

mottled black and white markings

2½–5 ft
0.8–1.5 m

21 in
53 cm

RED-CRESTED BUSTARD
Lophotis ruficrista
F: Otidae

Like other bustards, this southern African species has a spectacular courtship display. Males perform tumbling aerial flights, and pairs call in duet.

KORI BUSTARD
Ardeotis kori
F: Otidae

Among the heaviest flying birds, weighing up to 42 lb (19 kg), this bustard occurs across eastern and southern Africa. It feeds on small vertebrates, carrion, and seeds.

AUSTRALIAN BUSTARD
Ardeotis australis
F: Otidae

This bustard inhabits grasslands and open woodland of Australia and southern New Guinea. Males have a throat sac, which they inflate when displaying.

RED-LEGGED SERIEMA
Cariama cristata
F: Cariamidae

Related to the extinct, predatory, giant terror birds, seriemas are natives of the grasslands of South America. This species has a sicklelike claw to dismember small prey.

30–35 in
75–90 cm

long crest

KAGU
Rhynochetos jubatus
F: Rhynochetidae

Confined to the forests of New Caledonia in the southwestern Pacific, the kagu lacks strong muscles necessary for flight. Instead, it uses its wings to glide and for display.

22 in
55 cm

white stripes

off-white plumage

SUNBITTERN
Eurypyga helias
F: Eurypygidae

This heronlike predator inhabits the humid forests of Central and South America. It flashes its colored wing spots for display or to startle intruders.

17–19 in
43–48 cm

6 in
15 cm

YELLOW-LEGGED BUTTONQUAIL
Turnix tanki
F: Turnicidae

Like other buttonquails, this east Asian species inhabits tropical grasslands. The females are more colorful, and compete for the drab males, who take care of the young.

olive-brown wings and body

mottled plumage

LIMPKIN
Aramus guarauna
F: Aramidae

Mostly nocturnal, this small cousin of cranes inhabits tropical American wetlands and uses its tweezerlike bill to extract snails from shells.

26–28 in
65–70 cm

long, gray legs

9–12 in
22–30 cm

11–13 in
28–33 cm

BUFF-BANDED RAIL
Gallirallus philippensis
F: Rallidae

Unlike some of the other Indo-Pacific *Gallirallus* species that are flightless or nearly so, this rail has managed to disperse to many oceanic islands, from the Philippines to New Zealand.

4–6 in
10–15 cm

BLACK RAIL
Laterallus jamaicensis
F: Rallidae

Belonging to a group of mostly tropical American ruddy-patterned crakes, this species breeds in North America, where it is the smallest rail.

5–7 in
13–18 cm

YELLOW RAIL
Coturnicops noveboracensis
F: Rallidae

One of several barred-backed rails, this tiny, secretive North American species is most easily detected by its nocturnal-clicking call.

7½–9 in
19–23 cm

BLACK CRAKE
Amaurornis flavirostra
F: Rallidae

This African crake is widespread south of the Sahara. Unlike many of its secretive relatives, it is often seen out in the open.

CORNCRAKE
Crex crex
F: Rallidae

This shy grassland crake is best identified by its rasping "crex crex" call. It breeds in Eurasia and overwinters in Africa.

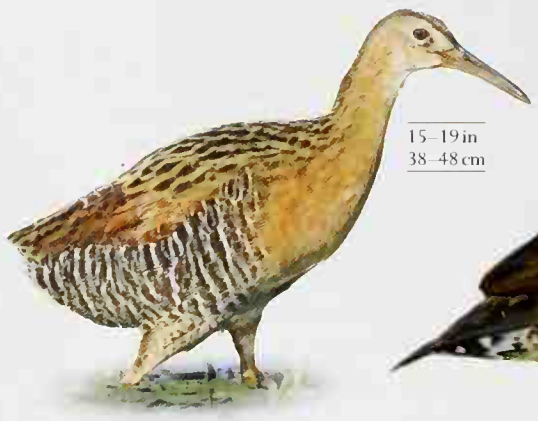
»

» CRANES AND RAILS

9–11 in
23–28 cm

WATER RAIL
Rallus aquaticus
F: Rallidae

Rallus rails are long-billed marsh birds with a narrow body for passing through reed beds. Like other members of the genus, this Eurasian bird is rarely seen away from dense cover.



15–19 in
38–48 cm

KING RAIL
Rallus elegans
F: Rallidae

This species is found in eastern North America, Mexico, and Cuba. It forages in concealed locations for insects, spiders, shrimps, and snails.

12½–16 in
32–41 cm

CLAPPER RAIL
Rallus longirostris
F: Rallidae

Unlike many other rails, this tropical American species prefers salt marshes and mangrove swamps. It has a distinctive clacking call.

8–10½ in
20–27 cm

VIRGINIA RAIL
Rallus limicola
F: Rallidae

This long-distance migrant has a range from North America to northern South America. It is a secretive bird that is difficult to spot.

12–14 in
30–36 cm

PURPLE GALLINULE
Porphyrio martinica
F: Rallidae

Occurring in tropical American marshes, this species belongs to a group of rails called swamphens. It is characterized by blue-purple plumage and a blue forehead shield.

7–9 in
18–22 cm

WHITE-BROWED CRAKE
Porzana cinerea
F: Rallidae

Shorter bills and distinctive calls distinguish crakes from rails. This gray-fronted bird is a typical *Porzana* crake. Its range extends from the Malay Peninsula to Polynesia.

8½–10½ in
21–27 cm

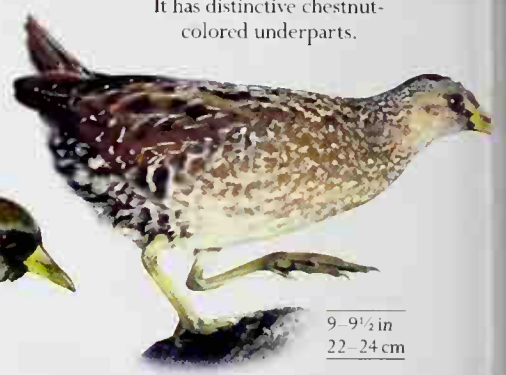
RUDDY-BREASTED CRAKE
Porzana fusca
F: Rallidae

This crake occurs in wetlands of eastern Asia, but is also seen in mangroves or drier habitats. It has distinctive chestnut-colored underparts.

8–10 in
20–25 cm

SORA RAIL
Porzana carolina
F: Rallidae

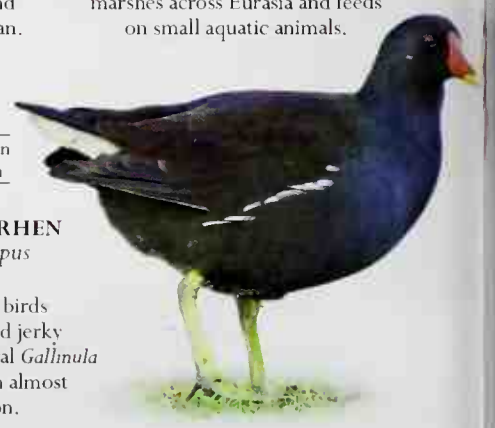
This crake is the most common member of the rail family in North America. It breeds in shallow wetland and winters in the Caribbean.



9–9½ in
22–24 cm

SPOTTED CRAKE
Porzana porzana
F: Rallidae

This shy bird hides in thick vegetation, and is detected by its whipcracklike call. It breeds in marshes across Eurasia and feeds on small aquatic animals.



12½–14 in
32–35 cm

COMMON MOORHEN
Gallinula chloropus
F: Rallidae

Moorhens are noisy birds with dark plumage and jerky movements. One of several *Gallinula* species, this one has an almost global distribution.

15–16 in
38–42 cm

RED-KNOBBED COOT
Fulica cristata
F: Rallidae

Coots are black rails with a white forehead shield and lobed toes. Occurring in Africa, Madagascar, and southern Spain, this species has two red knobs on its forehead.

15½–16 in
39–40 cm

AMERICAN COOT
Fulica americana
F: Rallidae

Found from North America to northern South America, this bird, unlike true rails, can swim. It forages in shallow water and feeds on land.

19–22 in
48–56 cm

20–25 in
50–63 cm

AFRICAN FINFOOT
Podica senegalensis
F: Heliornithidae

Streamlined swimming cousins of rails, finfoots are named for their web-lobed toes. This species occurs in wetlands in sub-Saharan Africa.

10–13 in
26–34 cm

SUNGREBE
Heliornis fulica
F: Heliornithidae

This species is a tropical American finfoot. Like all finfoots, it is a secretive bird of slow-moving water, where it feeds on small animals.

GREY-WINGED TRUMPETER
Psophia crepitans
F: Psophiidae

Named for their loud calls, trumpeters are gregarious Amazonian ground birds that are weak fliers. This is a black-bodied species, which—like other trumpeters—has a "hunchback" appearance.

red wattle

3½ ft
1.1 m

GREY CROWNED CRANE
Balearica regulorum
F: Gruidae

African crowned cranes are the only cranes that can grip branches, enabling them to roost in trees. This is the most southerly species.

gray-white plumage

bare red head

3½–4 ft
1–1.2 m

BROLGA
Grus rubicunda
F: Gruidae

This Australian crane has a bare red head and black dewlap (flap under the chin). It performs a spectacular prancing courtship display.

3½–3¾ ft
1–1.1 m

BLUE CRANE
Anthropoides paradiseus
F: Gruidae

The long wing plumes of this African crane resemble a tail. When not breeding, it is nomadic, frequenting lakeside, grassland, and farmland.

3½–4 ft
1–1.2 m

blue-gray plumage

4½–5 ft
1.4–1.5 m

RED-CROWNED CRANE
Grus japonensis
F: Gruidae

Declining in numbers, this bird breeds in Siberia and overwinters in Korea and China. The heaviest of all cranes, like related species it has a bare, red crown patch.

3½–4 ft
1–1.2 m

SANDHILL CRANE
Grus canadensis
F: Gruidae

A North American crane, this species also reaches westward into Siberia. It migrates south in family groups, as far as Mexico.

black wing feathers

3½–4 ft
1–1.2 m

COMMON CRANE
Grus grus
F: Gruidae

Frequenting marsh, heathland, and tundra, this bird breeds in Eurasia and migrates to northern Africa and southern Asia, often in a V formation.

juveniles lose their buff face feathers as they mature, leaving a patch of white cheek skin

red throat sac

neck feathers lack interlocking barbs, giving a loose, "hairy" appearance

^ CROWN AND COLOUR
This species sports a bristly golden crown, a neat black forehead, and hare white cheeks, edged with a patch of red, which is broader in East African birds. Both males and females have red throat sacs that can be inflated with air, then rapidly deflated to give a booming call.

GREY CROWNED CRANE

Balearica regulorum

Grey crowned cranes belong to the Gruidae family of birds, famous for their choreography; for these birds, dance is an important part of life. On the open savanna they display by jumping, flapping their wings, and bowing their heads—sometimes, it seems, just to relieve aggression or reinforce pair-bonding—but mainly to court their mates by flaunting their elaborate head ornamentation. They lack the long, coiled windpipe of the longer-billed crane species, so instead of calling like a bugle they honk like a goose. They also boom during courtship by puffing air from an inflated red throat sac. During the breeding season pairs retire to wetter habitats, where thicker vegetation conceals their nest—a circular platform made from grasses and sedges. Here, the chicks are hidden from predators, allowing the parents to roost, unlike other cranes, perched high in trees.

SIZE 3½ ft (1.1 m)
HABITAT Open country
DISTRIBUTION East and South Africa
DIET Grasses, seeds, invertebrates, small vertebrates

black head feathers give the appearance of a bulging forehead

nostril

bill is shorter and stouter than in other crane species

THIRD EYELID >
Also known as a nictitating membrane, from the Latin *nictare*, meaning "to blink," this translucent eyelid—the same as in other birds—moves across the eye to clean its surface.

GOLDEN PLUMES >
When the wings are folded, long, golden feathers on the upper wings—just above the flight feathers—hang down over the side of the body.

v RUFFLED NECK
Long, tapered contour feathers give the crowned crane a shaggy appearance around the upper part of the body and the lower part of the neck. Most of the bird's plumage is gray.

FEET AND CLAWS >
Crowned cranes have long hind toes, setting them apart from other crane species. This enables them to perch in trees—perhaps a vestige of tree-dwelling ancestors.

^ LONG LEGS
Although long legs help in dancing displays, and are good for wading, crowned cranes have shorter legs than those of other crane species.

white wing covert feathers

black primary flight feathers

brown secondary flight feathers

^ WING
When crowned cranes fly overhead, their white underwing patches are clearly visible. Although they have strong wings, these tropical birds—unlike other cranes—do not sustain long-distance migrations.

WADERS, GULLS, AND AUKS

Largely birds of coastal areas, waders are diverse in form and habit. Many are adapted for feeding in mud and water, with long legs and probing bills.

The birds collectively known as waders, or Charadriiformes, fall into three main groups. Of these, two groups are made up of shorebirds. Plovers and allied species are mostly short-legged, short-billed birds that feed on small invertebrates found close to the surface of the ground. Some birds in this group, such as lapwings, favor drier habitats inland. Other species in the plover group are more adapted to wetland. Stilts and avocets sweep shallow water with their needlelike bills, while oystercatchers use their long stout bills for opening mollusk shells. In the group consisting of sandpipers, snipe, and allies, birds also have long bills for probing deep mud. Some of their relatives, such as shanks and curlews, have long legs, too, so they can wade into deeper water to feed.

OCEANIC BIRDS

The final group in this order is made up of gulls, terns, skuas, and auks—web-footed birds that are the most ocean-going of the order. They may spend much of their lives at sea and some travel immense distances on migration. Gulls are opportunistic predators that are also seen foraging far inland. Auks, distributed around the Arctic, are specialized for diving for ocean-swimming prey. Their black and white coloration gives them a superficial resemblance to penguins, but they are not close relatives.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	CHARADRIIFORMES
FAMILIES	19
SPECIES	379

DEBATE

ORIGIN OF A GULL

New species appear when populations diverge too much to interbreed with others. In this way it was thought that European herring gulls diverged from Asian ancestors that spread eastward to encircle the Arctic. Recent evidence suggests herring gulls descended from gulls isolated in the North Atlantic.

16–17½ in
40–44 cm

EURASIAN STONE CURLEW
Burhinus oedicnemus
F: Burhinidae

Named for their shrill curlewlike calls, the mostly nocturnal stone curlews are related to plovers. This widespread Eurasian species occurs in dry mudflats inland.

19½–22 in
49–55 cm

GREAT STONE CURLEW
Esacus recurvirostris
F: Burhinidae

Large *Esacus* stone curlews have chisel-like bills for hunting prey, such as crabs, near water. This is a southern Asian species.

13½–16 in
34–41 cm

SNOWY SHEATHBILL
Chionis albus
F: Chionidae

This is one of two white sheathbills, Antarctic cousins of plovers, which scavenge and consume carrion and the food and young of other birds.

15–16 in
38–41 cm

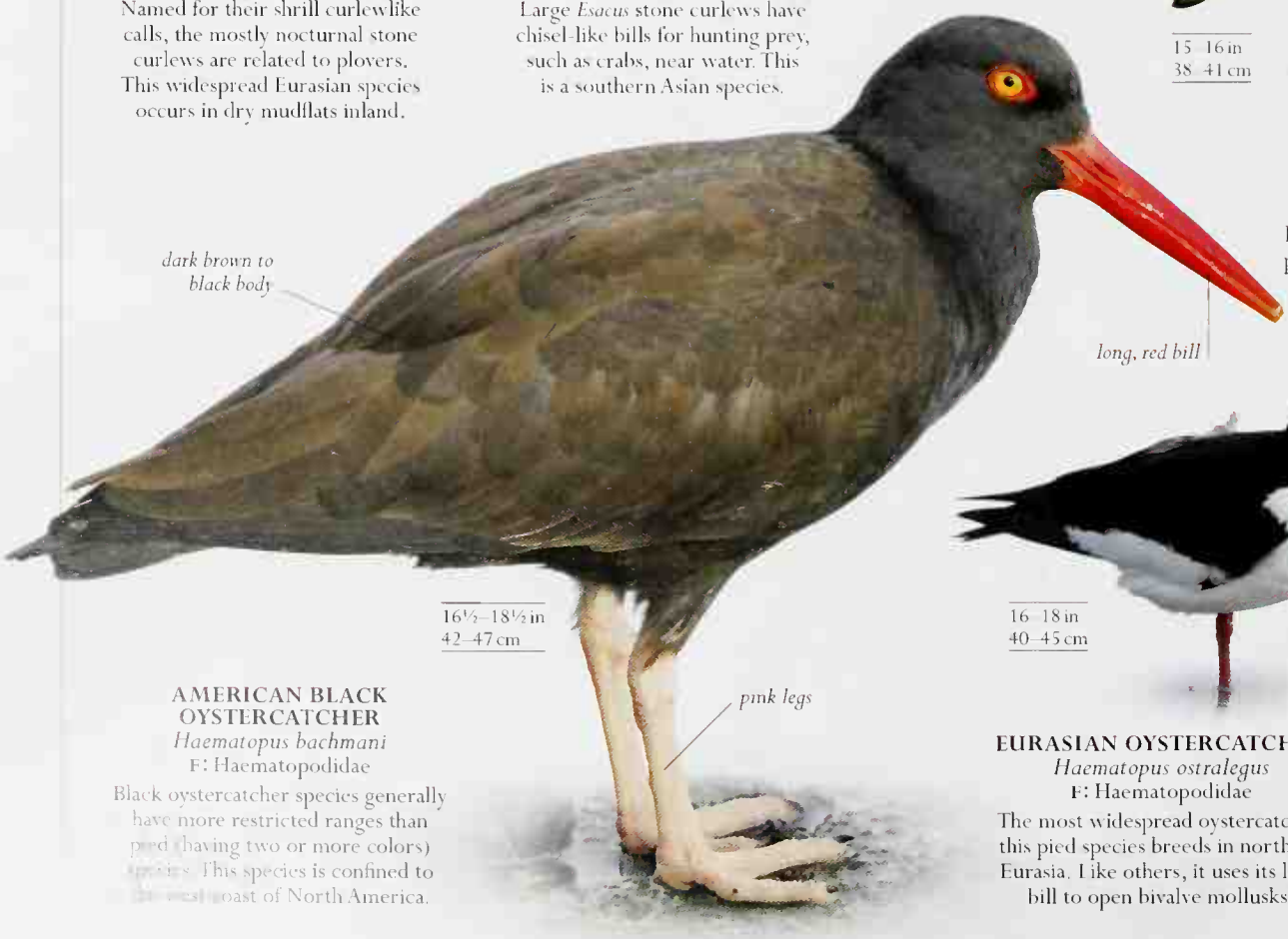
IBISBILL
Ibidorhyncha struthersii
F: Ibidorhynchidae

The only plover relative with a long, downcurved bill, this bird plucks invertebrates from stony riverbeds in mountains of Central Asia.

8–9 in
20–22 cm

MAGELLANIC PLOVER
Pluvianellus socialis
F: Chionidae

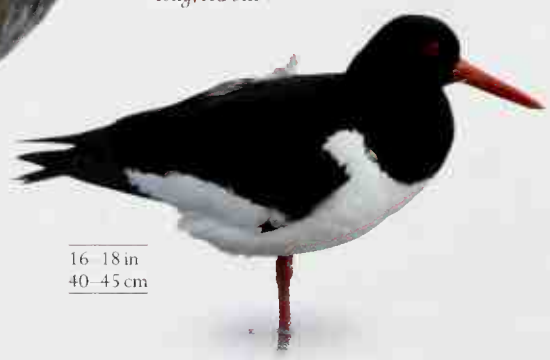
This unusual South American wader—the only one that regurgitates food for its chicks—is more closely related to sheathbills than to plovers.



16½–18½ in
42–47 cm

AMERICAN BLACK OYSTERCATCHER
Haematopus bachmani
F: Haematopodidae

Black oystercatcher species generally have more restricted ranges than pied (having two or more colors) species. This species is confined to the west coast of North America.



16–18 in
40–45 cm

EURASIAN OYSTERCATCHER
Haematopus ostralegus
F: Haematopodidae

The most widespread oystercatcher, this pied species breeds in northern Eurasia. Like others, it uses its long bill to open bivalve mollusks.

13–16 in
33–40 cm

CRAB PLOVER
Dromas ardeola
F: Dromadidae

The crab plover may be more closely related to gulls than to true plovers. Found around Indian Ocean coastlines, it uses its stout bill for eating crabs.

BANDED STILT
Cladorhynchus leucocephalus
F: Recurvirostridae

Stilts hunt small swimming invertebrates. This Australian species gathers in large flocks on salt lakes to feed on brine shrimp.

14–16 in
36–45 cm

RED-NECKED AVOCET
Recurvirostra novaehollandiae
F: Recurvirostridae

A nomadic bird of Australian wetlands, this distinctively marked wader is a social species that feeds in large flocks.

16–18 in
40–46 cm

PIED AVOCET
Recurvirostra avosetta
F: Recurvirostridae

This Eurasian wader is typical of avocets' relatives of stilts that take small aquatic animals by sweeping their upturned bills through water.

17–18 in
42–45 cm

WRYBILL
Anarhynchus frontalis
F: Charadriidae

Related to lapwings, this wader from New Zealand is the only bird with a bill bent sideways, which it uses to reach invertebrates under stones.

8 in
20 cm

BLACK-WINGED STILT
Himantopus himantopus
F: Recurvirostridae

This highly variable stilt is nearly global in distribution. There are white-necked and black-necked forms that may be separate species.

13–14 in
33–36 cm

INLAND DOTTEREL
Peltohyas australis
F: Charadriidae

This sand-colored relative of lapwings is found in arid parts of Australia, often far from water.

7½–9 in
19–23 cm

SPUR-WINGED PLOVER
Vanellus spinosus
F: Charadriidae

Occurring in wetlands across Africa and the Middle East, this bird is one of several lapwings, such as masked and southern, with a spur on each wing.

10–10½ in
25–27 cm

BLACK-BELLIED PLOVER
Pluvialis squatarola
F: Charadriidae

The only member of the golden plover group with gray, not yellow, speckled upperparts, this species breeds around the Arctic coastal tundra.

10–12 in
25–30 cm

EURASIAN GOLDEN PLOVER
Pluvialis apricaria
F: Charadriidae

Golden plovers are more closely related to stilts and oystercatchers than they are to other plovers. This species develops a black belly when breeding.

10–11½ in
26–29 cm

MASKED LAPWING
Vanellus miles
F: Charadriidae

Many lapwings have yellow, fleshy wattles. These facial adornments are especially prominent on this species from Australasia.

14–15 in
35–38 cm

NORTHERN LAPWING
Vanellus vanellus
F: Charadriidae

Lapwings are named for the lapping sound of their flight. This Eurasian species has a distinctive, pointed crest. It is also called a peewit for its unique call.

11–12 in
28–31 cm

COMMON RINGED PLOVER
Charadrius hiaticula
F: Charadriidae

One of the most widespread ring-necked plovers, this species breeds around the Arctic and overwinters in Africa and southwestern Asia.

7–8 in
18–20 cm

KILLDEER
Charadrius vociferus
F: Charadriidae

This long-tailed, grassland plover migrates between North and South America, but has resident populations in Peru and Chile.

9–10½ in
23–27 cm

EURASIAN DOTTEREL
Charadrius morinellus
F: Charadriidae

Females of this tundra-breeding bird are more brightly colored than males, but like many other plovers both become duller in winter.

8–9 in
20–22 cm

» WADERS, GULLS, AND AUKS

11–12 in
28–31 cm

BRONZE-WINGED JACANA
Metopidius indicus
F: Jacanidae

This species is widespread across India and Southeast Asia. Males have a flattened "forearm" bone that helps them lift chicks with their wings.

9–12 in
23–31 cm

AFRICAN JACANA
Actophilornis africanus
F: Jacanidae

Typical of the jacana family, this African wetland bird has large feet that enable it to walk on floating vegetation.

8–10½ in
20–27 cm

COMB-CRESTED JACANA
Irediparra gallinacea
F: Jacanidae

Found from Asia to Australia, this species is named for its fleshy head wattle. As with other jacanas, males incubate the eggs and care for the young.

12–23 in
31–58 cm

PHEASANT-TAILED JACANA
Hydrophasianus chirurgus
F: Jacanidae

This south Asian spur-winged jacana is the only species that changes plumage—losing its long tail—outside the breeding season.

6½–9 in
17–23 cm

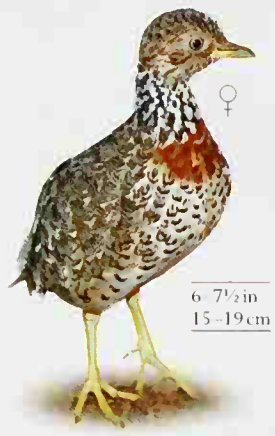
WATTLED JACANA
Jacana jacana
F: Jacanidae

The dominant female of this South American species breeds with many males, perhaps to compensate for crocodile predation of eggs.

9–10 in
23–26 cm

GREATER PAINTED-SNIPE
Rostratula benghalensis
F: Rostratulidae

Related to the jacanas, the short-legged painted-snipes share their female-dominant mating system. This bird is from Old World tropical wetlands.



6–7½ in
15–19 cm

PLAINS WANDERER
Pedionomus torquatus
F: Pedionomidae

This quail-like bird of Australian grassland—the only member of its family—is actually related to the wetland jacanas.

9–10 in
23–25 cm

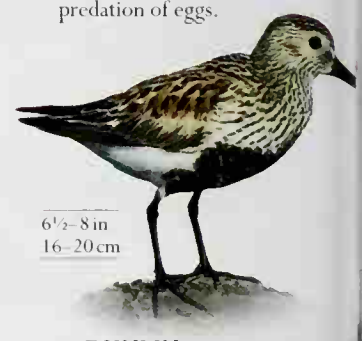
SHORT-BILLED DOWITCHER
Limnodromus griseus
F: Scolopacidae

Dowitchers are related to snipes and are reddish in their breeding plumage. The short-billed dowitcher is confined to the Americas.

9–10 in
23–25 cm

RED KNOT
Calidris canutus
F: Scolopacidae

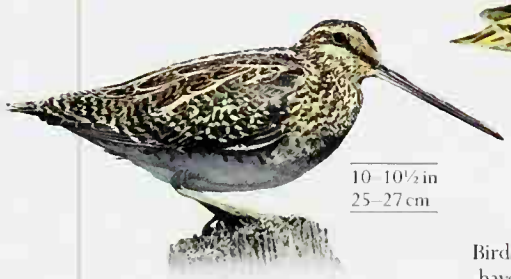
Like many migratory waders, the Arctic-breeding red knot molts its distinctive summer plumage to more drab colors in winter.



6½–8 in
16–20 cm

DUNLIN
Calidris alpina
F: Scolopacidae

Globally common, the dunlin is typical of waders that breed around the Arctic and flock to the warmer south in the winter.



10–10½ in
25–27 cm

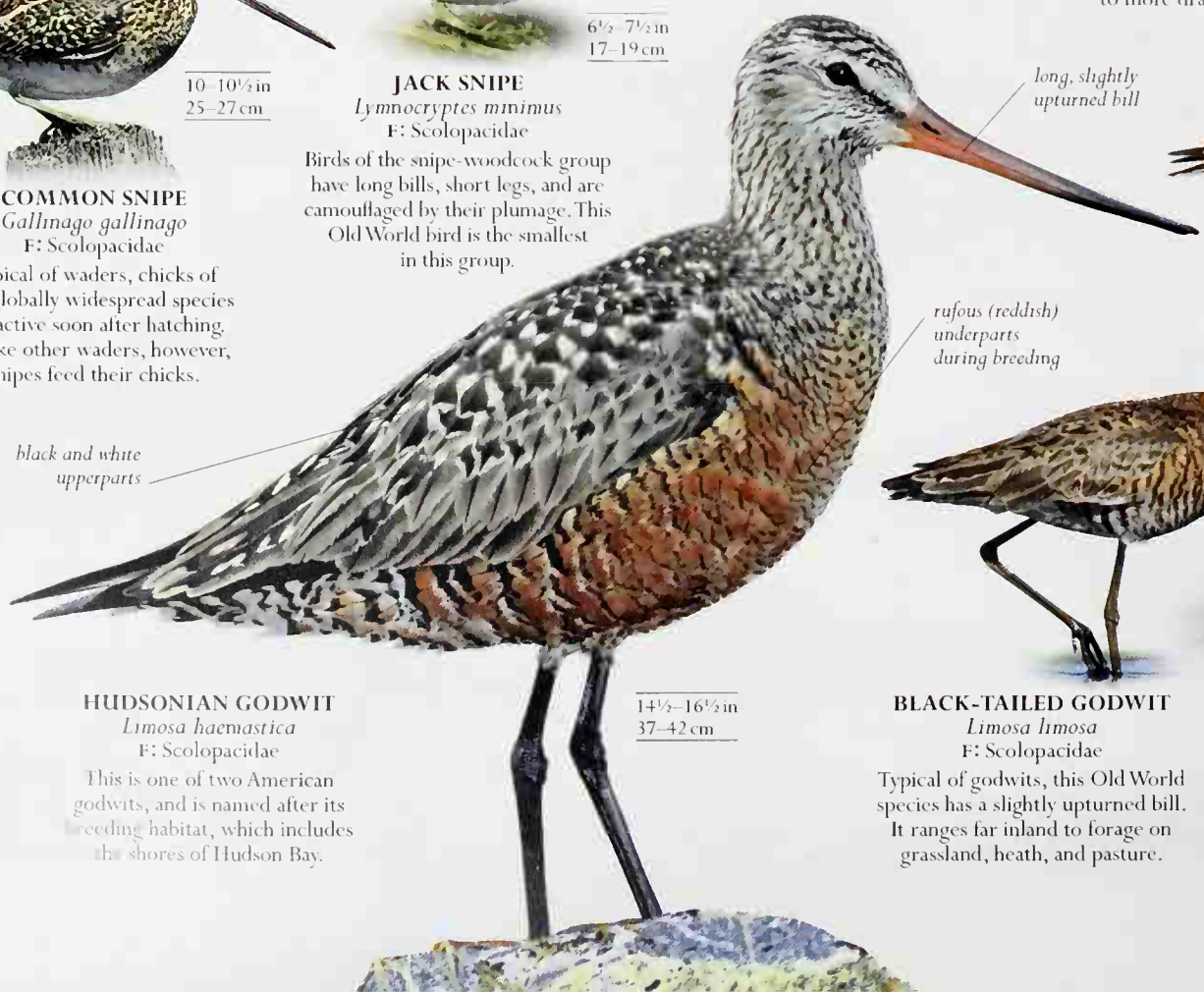
COMMON SNIPE
Gallinago gallinago
F: Scolopacidae

Typical of waders, chicks of this globally widespread species are active soon after hatching. Unlike other waders, however, snipes feed their chicks.

6½–7½ in
17–19 cm

JACK SNIPE
Lymnocryptes minimus
F: Scolopacidae

Birds of the snipe-woodcock group have long bills, short legs, and are camouflaged by their plumage. This Old World bird is the smallest in this group.



14½–16½ in
37–42 cm

HUDSONIAN GODWIT
Limosa haemastica
F: Scolopacidae

This is one of two American godwits, and is named after its breeding habitat, which includes the shores of Hudson Bay.

16–17½ in
40–44 cm

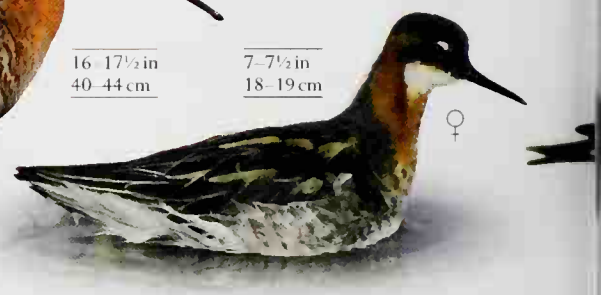
BLACK-TAILED GODWIT
Limosa limosa
F: Scolopacidae

Typical of godwits, this Old World species has a slightly upturned bill. It ranges far inland to forage on grassland, heath, and pasture.

8–8½ in
20–21 cm

SANDERLING
Calidris alba
F: Scolopacidae

This sandpiper breeds within the Arctic Circle, farther north than other waders. In winter, it flocks on sandy shores farther south.



7–7½ in
18–19 cm

RED-NECKED PHALAROPE
Phalaropus lobatus
F: Scolopacidae

This species has a breeding range that includes much of the Arctic region. Females are brightly colored and attract males with displays during breeding; males care for offspring.

18–26 in
45–66 cm

LONG-BILLED CURLEW
Numenius americanus
F: Scolopacidae

A typical curlew, this American species is a large wader with a long, downcurved bill for probing deeply in mud for invertebrate prey.

16–16½ in
40–42 cm

WHIMBREL
Numenius phaeopus
F: Scolopacidae

The smallest curlew, it has a distinctive trilling call and breeds in circumpolar regions. Some individuals winter as far away as Australia.

7–8 in
18–20 cm

BUFF-BREASTED SANDPIPER
Tryngites subruficollis
F: Scolopacidae

This wader breeds in the tundra of North America and extreme eastern Siberia. It winters in the grasslands of South America.

10½–11½ in
27–29 cm

COMMON REDSHANK
Tringa totanus
F: Scolopacidae

Most waders breed near fresh water, but the Old World common redshank—named after its colored legs—may sometimes breed on salt marshes.

9–10 in
23–25 cm

LESSER YELLOWLEGS
Tringa flavipes
F: Scolopacidae

Yellowlegs belong to the shank group. This species breeds in forests in Alaska and Canada, and overwinters in the Caribbean.

10–12 in
26–30 cm

WANDERING TATTLER
Tringa incana
F: Scolopacidae

This shank species breeds in Alaska, during which its breast is barred. It winters farther south along the Pacific coastline of America.

10–11 in
26–28 cm

AMERICAN WOODCOCK
Scolopax minor
F: Scolopacidae

Like other woodcocks and snipes, this American bird is superbly camouflaged and its eyes are placed high, enabling all-round vision to spot predators.

large neck ruff in breeding male

8–12 in
20–30 cm

RUFF
Philomachus pugnax
F: Scolopacidae

Males of this Old World marsh and meadow species transform during breeding: they lose their gray winter plumage and take on a rufous and black coloration, with a showy neck ruff.

7–8 in
18–20 cm

black spotted crown and belly in summer

reddish legs

SPOTTED SANDPIPER
Actitis macularius
F: Scolopacidae

Like the related common sandpiper (*A. hypoleucos*) from Eurasia, this American sandpiper has a short bill for pecking food from dry ground.

9–9½ in
22–24 cm

RUDDY TURNSTONE
Arenaria interpres
F: Scolopacidae

This bird, which breeds across the Northern Hemisphere, is named for the way it flips objects to search for prey.

5½–6½ in
14–16 cm

SPOON-BILLED SANDPIPER
Eurynorhynchus pygmeus
F: Scolopacidae

Like spoonbills, this wader from eastern Asia uses its distinctive spoon-shaped bill to sweep shallow water for invertebrate prey.

10½–11½ in
27–29 cm

WHITE-BELLIED SEEDSNIPE
Attagis malouinus
F: Thinocoridae

Four species of short-billed, herbivorous seedsnipes live in the open habitats of South America. This species is confined to the southern tip.

»

7⅛–8½ in
19–21 cm

CREAM-COLORED COURSER
Cursorius cursor
F: Glareolidae

Often nocturnal, coursers are inconspicuous, long-legged ground birds, similar to plovers. This is a migratory species from Asia and Africa.

7½–9½ in
19–24 cm

AUSTRALIAN PRATINCOLE
Stiltia isabella
F: Glareolidae

This pratincole from Australia and Indonesia usually stays close to freshwater, but has special glands that enable it to drink saltwater too.

9½–11 in
24–28 cm

BLACK-WINGED PRATINCOLE
Glareola nordmanni
F: Glareolidae

Like other pratincoles, this species is migratory. It breeds in eastern Europe and Central Asia and overwinters in Africa.

black-bordered creamy throat

forked tail

9–10 in
23–26 cm

10½–11 in
27–28 cm

HEUGLIN'S COURSER
Rhinoptilus cinctus
F: Glareolidae

Most coursers are restricted to arid deserts and scrub, but this African species also ventures into woodland habitats.

6½–7½ in
17–19 cm

LITTLE PRATINCOLE
Glareola lactea
F: Glareolidae

This small species is from southern Asia. Like its relatives, the little pratincole feeds on insects in flight. It has a forked tail.

COLLARED PRATINCOLE
Glareola pratincola
F: Glareolidae

Like most pratincoles, this species from southern Europe and Africa gathers in large, noisy flocks on open wetlands.

20–23½ in
50–60 cm

SWALLOW-TAILED GULL
Creagrus furcatus
F: Laridae

The only nocturnal gull, this species breeds on the Galapagos Islands and overwinters in South America. It feeds on fishes and squid.

16½–18 in
42–45 cm

SOOTY GULL
Larus hemprichii
F: Laridae

As with many warm-region gulls, this species from Asia and Africa has dark plumage, which may have evolved as an adaptation to strong sunshine.

20½–23½ in
52–60 cm

HERRING GULL
Larus argentatus
F: Laridae

Related to the lesser black-backed gull (*L. fuscus*), this species is often seen in coastal towns in eastern North America and in Europe.

13½–14½ in
34–37 cm

COMMON BLACK-HEADED GULL
Larus ridibundus
F: Laridae

Like other members of the hooded gull group, this dark-headed gull becomes white headed in winter. It is abundant in the Northern Hemisphere.

14–16 in
36–41 cm

LAUGHING GULL
Larus atricilla
F: Laridae

An American hooded gull, this species is named for its laughing call. It is a colonial breeder on coastal estuaries and salt marshes.

black-tipped red bill

18–21 in
46–53 cm

HEERMANN'S GULL
Larus heermanni
F: Laridae

This dark gull from North America is actually related to northern white-headed gulls. It often forages with brown pelicans and steals their food.

grey body

24–27 in
62–68 cm

GLAUCOUS GULL
Larus hyperboreus
F: Laridae

A large, Arctic-breeding species, this coastal gull is much paler than most related white-headed gulls found in the Northern Hemisphere.

RING-BILLED GULL
Larus delawarensis
F: Laridae

Breeding in North America and overwintering in the Caribbean, this species has a dark bill ring. It often forages on agricultural land.

18–20 in
46–51 cm

15½–17 in
39–43 cm

WHITE-EYED GULL
Larus leucophthalmus
F: Laridae

This relative of the sooty gull is confined to the Red Sea region, where it is threatened by oil spills.

20–26 in
50–67 cm

PACIFIC GULL
Larus pacificus
F: Laridae

Belonging to a group of southern gulls with banded tails, this large-billed Australian species cracks open shellfish by dropping them on rocks.

11–12 in
28–30 cm

BONAPARTE'S GULL
Larus philadelphia
F: Laridae

A North American hoodedf gull, this species breeds in wet coniferous forests in Canada and winters along Caribbean coasts.

22–26 in
55–66 cm

WESTERN GULL
Larus occidentalis
F: Laridae

This large gull is found on the Pacific coast of North America. It nests in colonies, usually offshore on islands or rocks.

16–16½ in
40–42 cm

MEW GULL
Larus canus
F: Laridae

This Northern Hemisphere species, whose name derives from its distinctive call, is also called the common gull. It breeds inland on moors, as well as on the coast.

18–18½ in
45–47 cm

GREY GULL
Larus modestus
F: Laridae

Confined to Peru and Chile, this species breeds in the Atacama Desert, one of the driest regions of the world.

large white head

slaty black back and wings

25–31 in
64–78 cm

GREAT BLACK-BACKED GULL
Larus marinus
F: Laridae

The world's largest gull, this North Atlantic coastal bird is an aggressive predator and preys on other seabirds and their chicks.

pink feet

16–18 in
40–45 cm

SILVER GULL
Larus novaehollandiae
F: Laridae

Despite its different appearance, this Australian gull is related to the common black-headed gull. It visits human refuse sites to feed.

white-edged eye

tricolored bill

22½–24 in
57–61 cm

GREAT BLACK-HEADED GULL
Larus ichthyaetus
F: Laridae

One member of an Asian group of black-headed gulls, this species breeds in Russia and overwinters on Mediterranean and Indian ocean coasts.

narrow black collar

15–16 in
38–40 cm

wedge-shaped tail

16½–17½ in
42–44 cm

DOLPHIN GULL
Leucophaeus scoresbii
F: Laridae

This gull is famously aggressive to other birds. It is confined to the southern tip of South America and the Falkland Islands.

16–17 in
40–43 cm

IVORY GULL
Pagophila eburnea
F: Laridae

This Arctic gull is rarely found far from pack ice. It follows polar bears to scavenge at their kills.

ROSS'S GULL
Rhodostethia rosea
F: Laridae

A distinctive pink gull, Ross's gull breeds in swampy and wooded Arctic tundra, and winters along coasts and at sea.

yellow legs

10½–12½ in
27–32 cm

SABINE'S GULL
Xema sabini
F: Laridae

A relative of the ivory gull, this bird is an Arctic breeder, but it migrates long distances to overwinter in South America and Africa.

14–16 in
35–40 cm

RED-LEGGED KITTIWAKE
Rissa brevirostris
F: Laridae

This kittiwake breeds only on islands in the Bering Sea in the North Pacific and spends winter at sea farther south.

15–16 in
38–40 cm

BLACK-LEGGED KITTIWAKE
Rissa tridactyla
F: Laridae

The world's most abundant species of gull, this colonial cliff-nesting bird is found in the North Atlantic and Pacific oceans.

»

11–13 in
28–33 cm

WHITE TERN
Gygis alba
F: Laridae
This small all-white tern from the islands of the tropical Atlantic and Indian oceans is notable for laying its eggs on bare branches in trees.

16–16½ in
40–42 cm

INCA TERN
Larosterna inca
F: Laridae
A distinctively patterned bird, the inca tern is found in Peru and Chile, where it breeds on rocky coastlines.

white cheek stripe

bright red legs

14–14½ in
35–37 cm

LESSER CRESTED TERN
Sterna bengalensis
F: Laridae
In this relative of the greater crested tern, the bill changes from yellow to orange during breeding.

9–9½ in
22–24 cm

BLACK TERN
Chlidonias niger
F: Laridae
This small freshwater tern breeds in the wetlands of the Northern Hemisphere and winters in South America and Africa.

13–14 in
33–35 cm

ARCTIC TERN
Sterna paradisaea
F: Laridae
This tern migrates the greatest distance of any animal: from its Arctic breeding grounds to Antarctica. It feeds on fishes and crustaceans.

black cap

18½–21½ in
47–54 cm

9–9½ in
22–24 cm

LITTLE TERN
Sterna albifrons
F: Laridae
The Old World little tern belongs to a group of coastal species with a white "blaze" above the eye.

black markings on tips of underwings

13–14 in
33–36 cm

SOOTY TERN
Sterna fuscata
F: Laridae
This white-bridled sea tern breeds on tropical islands. It is also known as the wideawake tern because of its noisy colonies.

CASPIAN TERN
Sterna caspia
F: Laridae
The largest tern species, this bird is found in most continents. It is a colonial ground-nester, like most sea terns.

SAUNDERS'S TERN
Sterna saundersi
F: Laridae
A small tern from the Red Sea and Indian Ocean, Saunders's tern used to be considered a race of the little tern.

9–9½ in
23–24 cm

long, black legs

13–15 in
33–38 cm

12–12½ in
30–32 cm

BRIDLED TERN
Sterna anaethetus
F: Laridae
This tern of tropical and subtropical regions has a white forehead, or bridle, similar to little and sooty terns. It spends much time at sea.

ROSEATE TERN
Sterna dougallii
F: Laridae
Although widespread around the world, the roseate tern is not common anywhere, and breeds in a number of isolated colonies.

12½–13½ in
32–34 cm

WHITE-CHEEKED TERN
Sterna repressa
F: Laridae
This species from the Red Sea and Indian Ocean can be identified by its plumage, which is darker than that of other gray terns.

18–19½ in
46–49 cm

GREAT CRESTED TERN
Sterna bergii
F: Laridae
This Old World tern belongs to a group of related crested terns, characterized by a black nape tuft.

12–12½ in
30–32 cm

BLACK-NAPED TERN
Sterna sumatrana
F: Laridae
Found on the Indian and Pacific oceans, the black-naped tern nests in small colonies, usually apart from other terns.

16–20 in
40–50 cm

BLACK SKIMMER
Rynchops niger
F: Laridae

Skimmers are the only birds with projecting lower beak mandibles, used to skim water for fish. This species is found in North and South America.

16–18 in
40–45 cm

BROWN NODDY
Anous stolidus
F: Laridae

Noddies are dark or white, tropical members of the tern family. The largest species, the brown noddy, is widespread around the world.

stout, hooked bill

20½–21 in
52–54 cm

brownish gray body

SOUTH POLAR SKUA
Stercorarius maccormicki
F: Stercorariidae

This large bird, with a reputation for attacking other seabirds, is one of the few waders to breed on the Antarctic coast.

18–20 in
46–51 cm

POMARINE JAEGER
Stercorarius pomarinus
F: Stercorariidae

Jaegers (also called skuas in Europe) are aggressive gull-like birds. This Arctic species will kill and eat other seabirds and even attack humans that threaten its nest.

19–21 in
48–53 cm

LONG-TAILED JAEGER
Stercorarius longicaudus
F: Stercorariidae

Like other species, this smallest member of the jaeger family is migratory. It breeds in circumpolar regions and winters farther south.

16–18 in
41–46 cm

PARASITIC JAEGER
Stercorarius parasiticus
F: Stercorariidae

The most common jaeger in the Arctic, like most of its relatives it mobs other seabirds to steal their prey.

14½–15½ in
37–39 cm

RAZORBILL
Alca torda
F: Alcidae

The North Atlantic razorbill has a flattened, white-barred bill. As with other auks, its pointed eggs cannot roll off cliff-top breeding sites.

9½–10½ in
24–27 cm

CRESTED AUKLET
Aethia cristatella
F: Alcidae

Like other auklets, this North Pacific species feeds on planktonic crustaceans. Pairs anoint themselves with secretions from their backs during courtship.

9½–10 in
24–25 cm

MARBLED MURRELET
Brachyramphus marmoratus
F: Alcidae

This small American auk nests in trees in coniferous woods. Fledged chicks leave the nest at night and make for the sea.

6½–7½ in
17–19 cm

DOVEKIE
Alle alle
F: Alcidae

This tiny auk breeds on Arctic islands and winters at sea farther south. It feeds on tiny fishes and crustaceans.

12–14 in
30–36 cm

white wing patch

red feet

PIGEON GUILLEMOT
Cepphus columba
F: Alcidae

This North Pacific auk, fully adapted to cold conditions, cannot migrate south through warmer waters, just as Southern Hemisphere penguins cannot move northward.

12–12½ in
30–32 cm

11–11½ in
28–29 cm

BLACK GUILLEMOT
Cepphus grylle
F: Alcidae

This species of northern North American and Eurasian coasts breeds in sparser colonies than other auks and winters mainly inshore.

RHINOCEROS AUKLET
Cerorhinca monocerata
F: Alcidae

This North Pacific relative of puffins shares their burrow-nesting habits, and is named for the hornlike bill projection in breeding adults.

dark brown to black head

15–16 in
38–41 cm

COMMON MURRE
Uria aalge
F: Alcidae

A typical diving member of the auk family, this bird breeds on North Atlantic and Pacific coasts, and winters at sea.

10–11¼ in
26–29 cm

ATLANTIC PUFFIN
Fratercula arctica
F: Alcidae

A small, North Atlantic member of the auk family, this species—like other puffins—nests in colonies, in burrows, usually below turf.

13½–14 in
34–36 cm

TUFTED PUFFIN
Fratercula cirrhata
F: Alcidae

Like its Atlantic relative, this larger Pacific puffin catches small fish and can hold many at a time, crosswise, in its bill.

SANDGROUSE

Sand-colored plumage camouflages these birds in their desert habitats, where they are well adapted for living in an extremely dry environment.

With their rounded bodies and short legs, sandgrouse might be mistaken for partridges until they take flight, darting quickly and acrobatically in the air. These birds, the Pteroclidiformes, are found in arid areas of Asia, Africa, Madagascar, and southern Europe. They are not related to the subarctic grouse species but are more closely related to pigeons.

Sandgrouse have long pointed wings and all species have cryptic plumage—mottled on the back, but often boldly marked with brown or white stripes or blotches on the head and underparts. They are social birds that gather in flocks to make early-morning, or sometimes evening, forays to drinking holes, often traveling considerable distances. They feed exclusively on seeds.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PTEROCLIDIFORMES
FAMILIES	1
SPECIES	16

WATER CARRIERS

Sandgrouse breed during the rainy season to take advantage of seed harvests. Their nest is nothing more than shallow depression on the ground. Both parents incubate and care for their young. Remarkably, the males supply water to their chicks, which are normally raised far from water sources. The male's belly feathers soak up and retain moisture when the bird visits a drinking hole. Back at the nest, the chicks drink from the parent's soaked feathers.

Namaqua sandgrouse drink at a watering hole. Like all sandgrouse, they gather in large flocks to confuse predators.

PALLAS'S SANDGROUSE
Syrrhaptes paradoxus
F: Pteroclididae
One of two Central Asian sandgrouse, this large species has feathered toes, a long tail, and a long flight feather on each wing.

12–16 in
30–41 cm

barred buff plumage

long, pointed tail

DOUBLE-BANDED SANDGROUSE
Pterocles bicinctus
F: Pteroclididae
A bird of southern African savanna and open woodland, this is one of several sandgrouse species in which the males have distinctive belly stripes.

10–11 in
25–28 cm

black and white bands on forecrown (male only)

CHESTNUT-BELLIED SANDGROUSE
Pterocles exustus
F: Pteroclididae
This bird of open desert gathers in huge flocks, in a range that extends from Senegal to Kenya, and east as far as India.

12–13 in
31–33 cm

white-barred wings

black breast band

10½–12 in
27–30 cm

CROWNED SANDGROUSE
Pterocles coronatus
F: Pteroclididae
This yellow-throated sandgrouse is found from the stony desert of the Sahara to Pakistan. It can tolerate high temperatures and even brackish water.

9½–10 in
24–26 cm

LICHTENSTEIN'S SANDGROUSE
Pterocles lichtensteinii
F: Pteroclididae
This small bird is less gregarious than other species of sandgrouse. It inhabits bushy scrubland, and semidesert regions from North and East Africa to Pakistan.

PIGEONS AND DOVES

This is a highly successful group of seed-eating and fruit-eating birds that are distributed almost worldwide outside the coldest regions.

After the parrots, pigeons and doves form the largest group of vegetarian tree-perching birds: the order Columbiformes. However, whereas parrots have heavy hooked bills for cracking large nuts, pigeons have less robust bills for feeding on smaller seeds and grain. Some tropical groups, such as the Indo-Pacific fruit doves, are specialized fruit-eaters of the rain forest canopy.

Most birds in this order are short-legged and a few spend almost all of their time on the ground. Pigeons and doves are unusual among birds in being able to suck up water when drinking without tilting back their head, owing to a pumping action in their food pipe. This allows them to drink continuously, which is a particular benefit in arid environments. They can store food in their bill, and they feed their chicks on a secretion from the bill that is similar to mammalian milk.

THREATS AND EXTINCTIONS

The success of many pigeon species is due to high rates of reproduction. However, some species are threatened by humans and others have already been lost. The 17th-century demise of the dodo, a vulnerable flightless species, was the result of human impact. And the passenger pigeon, once one of North America's most common birds, was hunted to extinction in the 1900s.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	COLUMBIFORMES
FAMILIES	2
SPECIES	321

DEBATE

A MODIFIED PIGEON?

Mid-19th-century scientists placed the extinct flightless dodo from Mauritius in the pigeon order, and recent analysis indicates that it was related to the Nicobar pigeon. So the dodo was really a modified pigeon, with Indo-Pacific ancestors that might already have been flightless.

EUROPEAN TURTLE DOVE
Streptopelia turtur
F: Columbidae

With a range from Africa to Eurasia, turtle doves are small, slim relatives of *Columba* pigeons. Many, such as this western species, have distinctive neck markings.

black and white striped neck patch

10–11 in
26–28 cm

LAUGHING DOVE
Streptopelia senegalensis
F: Columbidae

Common in villages and oases in Africa and southern Asia, this turtle dove is named after its distinctive chuckling song.

10–10½ in
25–27 cm

red patch around eyes

white speckled wings

15–17 in
38–43 cm

BROWN CUCKOO-DOVE
Macropygia amboinensis
F: Columbidae

Long-tailed *Macropygia* doves are cuckoolike birds of Indo-Pacific rain forests. Like others, this species from the Moluccas (Indonesia), New Guinea, and Australia has many races.

10–11 in
26–28 cm

NAMAQUA DOVE
Oena capensis
F: Columbidae

This long-tailed, ground-feeding species belongs to a group of small African wood doves. Its range extends into Madagascar and Saudi Arabia.

13–15 in
33–38 cm

SPECKLED PIGEON
Columba guinea
F: Columbidae

This large African pigeon is common in open country south of the Sahara, and it often gathers around towns and villages.

12½ in
32 cm

PINK PIGEON
Nesoenas mayeri
F: Columbidae

Possibly related to turtle doves, this rare bird is restricted to Mauritius. Its once threatened population recovered due to a successful captive-breeding program.

15–17 in
38–43 cm

WOODPIGEON
Columba palumbus
F: Columbidae

This large western Eurasian pigeon is commonly found in woods and farmland, and often enters parks and gardens.

12–14 in
31–35 cm

ROCK PIGEON
Columba livia
F: Columbidae

True wild pigeons inhabit cliffs and hedges. In its natural environment, this species lives in mountainous regions of Europe and Asia.

12–14 in
31–35 cm

DOMESTIC PIGEON
Columba livia
F: Columbidae

Domesticated and feral descendants of the rock pigeon are found in urban areas worldwide. These birds have variable plumage patterns.

»

» PIGEONS AND DOVES

13–16 in
33–40 cm

NICOBAR PIGEON
Caloenas nicobarica
F: Columbidae

Possibly related to the extinct Mauritian dodo, this pigeon inhabits coastal regions and island forests from Malaysia to New Guinea.

6½–9 in
17–23 cm

INCA DOVE
Columbina inca
F: Columbidae

From arid regions of the southern USA and Central America, this species belongs to a group of mostly drab-colored tropical American ground-doves.

8 in
20 cm

DIAMOND DOVE
Geopelia cuneata
F: Columbidae

A small, nomadic bird from the dry interiors of Australia, this dove occurs in groups, flocking in large numbers at watering holes.

WOMPOO FRUIT DOVE
Ptilinopus magnificus
F: Columbidae

Fruit doves are multicolored relatives of imperial pigeons (*Ducula* sp.). This large species from New Guinea and Australia lives in the rain forest canopy.

yellow markings on wings

11½–22 in
29–55 cm

10–12 in
25–31 cm

WHITE-TIPPED DOVE
Leptotila verreauxi
F: Columbidae

A tropical relative of the mourning dove, this species is widespread in Central and South America, and reaches as far north as Texas.

dark green tail

12 in
30 cm

14 in
35 cm

9–13½ in
23–34 cm

dark pink head and breast

emerald-green wings and back

9–11 in
23–28 cm

EMERALD DOVE
Chalcophaps indica
F: Columbidae

An iridescent green bird, this ground-feeding species occurs in rain forests from India to islands of the southwest Pacific. It has a diet of fruits and seeds.

MINDANAO BLEEDING-HEART PIGEON
Gallicolumba criniger
F: Columbidae

The five species of Philippine bleeding-heart pigeons are named for their blood-red breast spots. This bird inhabits the southern islands of the archipelago.

SULAWESI GROUND DOVE
Gallicolumba tristigmata
F: Columbidae

From the forests of Sulawesi, Indonesia, this terrestrial bird is related to Philippine bleeding-heart pigeons, and perhaps to various doves of arid Australia.

MOURNING DOVE
Zenaida macroura
F: Columbidae

Named for its mournful call, this long-tailed dove occurs in open country throughout North and Central America, and the Caribbean.

16–18 in
40–46 cm

TOPKNOT PIGEON
Lopholaimus antarcticus
F: Columbidae

A large hawklike pigeon from eastern Australia, this species is named for the double crest of feathers on its forecrown and crown.

18 in
45 cm

GREEN IMPERIAL PIGEON
Ducula aenea
F: Columbidae

Found in rain forest canopy from India to southeast Asia, this large bird has a deep, booming call and its diet consists primarily of fruits.

15½–17½ in
39–44 cm

PIED IMPERIAL PIGEON
Ducula bicolor
F: Columbidae

Imperial pigeons are large, fruit-eating rain forest birds. This species from southeast Asia and Australasia has a white plumage that is often stained due to its diet.

29–30 in
74–75 cm

VICTORIA CROWNED PIGEON
Goura victoria
F: Columbidae

Crowned pigeons are the largest of the pigeons. This bird from northern New Guinea is distinguished from the southern crowned pigeon by its white-tipped crest.

14–15 in
36–38 cm

WONGA PIGEON
Leucosarcia melanoleuca
F: Columbidae

Confined to eastern Australia, this distinctively patterned pigeon inhabits woodland and scrub from southern Queensland to Victoria.

side flattened tail

18–20 in
45–50 cm

PHEASANT PIGEON
Otidiphaps nobilis
F: Columbidae

Recent research suggests this New Guinean ground pigeon belongs to a group that includes crowned pigeons and perhaps even the extinct dodo.

fanlike crown

SOUTHERN CROWNED PIGEON
Goura scheepmakeri
F: Columbidae

This species inhabits the forests of the southern part of New Guinea. It has bluish gray upperparts, a maroon chest, and a lacy crest.

30 in
75 cm

bluish gray plumage

maroon chest

white wing patch

10½–12 in
27–31 cm

KEY WEST QUAIL-DOVE
Geotrygon chrysia
F: Columbidae

Quail-doves are birds of tropical American forests. This iridescent species occurs in the Caribbean, including the Bahamas.

10–11 in
25–28 cm

AFRICAN GREEN PIGEON
Treron calvus
F: Columbidae

More than 20 species of *Treron* pigeons occur in the tropical regions of Africa and Asia. This species is widespread south of the Sahara.

13–14 in
33–36 cm

COMMON BRONZEWING
Phaps chalcoptera
F: Columbidae

Bronzewings are fast-flying Australian pigeons that feed on the ground. They have iridescent wing patches, which are particularly extensive in this widespread woodland species.

grayish body

8–9 in
20–22 cm

12–14 in
31–35 cm

iridescent wing patch

SPINIFEX PIGEON
Geophaps plumifera
F: Columbidae

This Australian bronzewing pigeon is found in arid, rocky habitats with an abundance of spinifex grass, in which it nests.

CRESTED PIGEON
Ocyphaps lophotes
F: Columbidae

One of several species of Australian bronzewing pigeons, this species is widespread in open country throughout the continent.

PARROTS AND COCKATOOS

Most parrots are birds of tropical forests, although a few favour open habitats. This order, the Psittaciformes, is diverse and often colorful.

The most recognizable feature of a parrot is its decurved bill. Both mandibles of the bill articulate with its skull: the upper mandible can move up, just as the lower can move down. This allows the bird not only to crack open hard seeds and nuts, but also to use its bill for gripping when clambering through trees. The legs are strong and the feet, with two forward-facing and two backward-facing toes, can grasp and manipulate foodstuffs. Bright colors are common, often in both sexes, with green plumage predominating. This color is the result of feather structure, which scatters light on yellow pigment. The Australasian cockatoos—parrots with distinctive erectile crests—lack this feather texture and so lack green and blue colors.

Australasia's high parrot diversity, which includes the brush-tongued, nectar-feeding lorikeets, suggests that the group originated in this part of the world. The most primitive parrots, the kea and the nocturnal, flightless kakapo, are both found in New Zealand.

SOCIAL SPECIES

Parrots are sociable, often living in large flocks, and almost all species form strong pair bonds. Their engaging personalities make them popular as pets, but the international cagebird trade has driven many species to the edge of extinction.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PSITTACIFORMES
FAMILIES	1
SPECIES	375

Green-winged macaws socialize at a clay lick, which provides sodium in an area where the mineral is very limited.

KEA
Nestor notabilis
F: Psittacidae

An opportunistic alpine omnivore, the kea eats carrion and live petrel chicks. It belongs to an ancient group of parrots in New Zealand that includes the kakapo.

19 in
48 cm

23½ in
60 cm

14 in
36 cm

GALAH
Eolophus roseicapilla
F: Psittacidae

The only cockatoo with a deep pink neck and underparts, this small relative of the white cockatoos is widespread throughout Australia in areas with scattered trees.

KAKAPO
Strigops habroptila
F: Psittacidae

The only flightless parrot, this large, nocturnal bird occurs in the small islands off New Zealand. Males make booming calls to attract females.

5–6 in
13–15 cm

VERNAL HANGING PARROT
Loriculus vernalis
F: Psittacidae

Hanging parrots are Indo-Pacific birds, even though recent genetic evidence suggests affinities with African lovebirds. Elsewhere it found from India to Thailand.

♀ ♂

4¾–6 in
12–15 cm

BLUE-CROWNED HANGING PARROT
Loriculus galgulus
F: Psittacidae

Hanging parrots, unusual among birds, sleep upside down. Like other such parrots, this small forest bird from Southeast Asia has a short tail and primarily green plumage.

19½ in
49 cm

SULPHUR-CRESTED COCKATOO
Cacatua galerita
F: Psittacidae

White cockatoos are screeching parrots with a range that extends from Indonesia to the Pacific Rim. This species occurs in New Guinea and Australia.

20–24 in
50–61 cm

RED-TAILED BLACK COCKATOO
Calyptorhynchus banksii
F: Psittacidae

One of several Australian black cockatoos with colored tail panels, this glossy species has a typical wailing call and ponderous wing beats.

♀
♂
12½ in
32 cm

COCKATIEL
Nymphicus hollandicus
F: Psittacidae

A bird of Australia's dry interior, this species resembles a parakeet, but its DNA shows that it is a miniature cockatoo.

13 in
30 cm

CHATTERING LORY
Lorius garrulus
F: Psittacidae

One of a group of green-winged red lories from New Guinea and surrounding islands, this species is from the Moluccas.

10 in
25 cm

DUSKY LORY
Pseudeos fuscata
F: Psittacidae

The patchy brown coloration of this species is unique among lories. This bird occurs in New Guinea and nearby islands.

12 in
30 cm

BLACK-WINGED LORY
Eos cyanogenia
F: Psittacidae

The *Eos* lories are vividly red and violet Indonesian birds. This is the easternmost species, restricted to the area around Geelvink Bay, New Guinea.

9½ in
24 cm

OLIVE-HEADED LORIKEET
Trichoglossus euteles
F: Psittacidae

Found on the island of Timor, this long-tailed relative of the rainbow lorikeet has bright green plumage, typical of many parrots.

7 in
18 cm

VARIED LORIKEET
Psitteuteles versicolor
F: Psittacidae

A small lorikeet from northern Australian woodlands, this species nests in eucalyptus tree cavities, like many other parrots in its habitat.

17 in
43 cm

AUSTRALIAN KING PARROT
Alisterus scapularis
F: Psittacidae

King parrots are rain forest birds from tropical Australasia and represent an evolutionary link to Asian parakeets. This species occurs in eastern Australia.

10–12 in
25–30 cm

RAINBOW LORIKEET
Trichoglossus haematodus
F: Psittacidae

A variable species, this bird is found in many habitats with nectar-giving blossom. Its range includes most of Australasia and the islands of the southwest Pacific.

♀
♂
13–15½ in
33–39 cm

ECLECTUS PARROT
Eclectus roratus
F: Psittacidae

Males and females of this parrot are so different they were originally classified as separate species. They are found in tropical Australasian rain forests.

7 in
18 cm

BUDGERIGAR
Melopsittacus undulatus
F: Psittacidae

A nomadic Australian bird, this small parrot from arid regions flocks to watering holes. Despite being a seed-eater, it is related to nectar-feeding lorikeets.

10½ in
27 cm

RED-FRONTED PARAKEET
Cyanoramphus novaezelandiae
F: Psittacidae

Small parakeets with colored foreheads have diversified in the southwest Pacific, and include the only parakeets—like this species—from New Zealand.

13½–15 in
34–38 cm

AUSTRALIAN RINGNECK
Barnardius zonarius
F: Psittacidae

Named for its yellow neck ring, this Australian bird has black- and green-headed forms. It is widespread in woodland.

»

» PARROTS AND COCKATOOS

14 in
36 cm

RED-FAN PARROT
Deroptyus accipitrinus
F: Psittacidae

Possibly related more closely to macaws than to other short-tailed parrots, this South American parrot raises a red neck ruff when excited.

♂

8 in
20 cm

♀

TURQUOISE PARROT
Neophema pulchella
F: Psittacidae

A member of a group of small, green grass parrots from Australia, the turquoise parrot is an open woodland bird from the southeast of the continent.

black mask

18½ in
47 cm

yellow belly

12 in
30 cm

EASTERN ROSELLA
Platycercus eximius
F: Psittacidae

Rosellas are broad-tailed parrots with a range from Australia to nearby Pacific islands. A typical rosella, this variable eastern Australian bird has white cheeks.

ROSE-RINGED PARAKEET
Psittacula krameri
F: Psittacidae

This is the most widespread Asian parakeet that reaches westwards into northern Africa. This species has also been introduced in Europe.

MASKED SHINING PARROT
Prosopeia personata
F: Psittacidae

One of the three species of shining parrots restricted to Fiji, this parrot is declining in numbers due to loss of its native forest.

blue plumage and upperparts

15–16½ in
38–42 cm

16–18½ in
40–47 cm

♀

♂

gray-black undertail

16 in
40 cm

SUPERB PARROT
Polytelis swainsonii
F: Psittacidae

This southeastern Australian bird belongs to a group of long-tailed Australian parrots and breeds in red gum forests. It is rapidly declining in number.

white face

13 in
33 cm

PRINCESS PARROT
Polytelis alexandrae
F: Psittacidae

A nomad from central Australia, this bird follows watercourses and gathers near spinifex grass. It often breeds in small colonies in eucalyptus trees.

yellow undertail

pale gray underparts

6 in
15 cm

YELLOW-COLLARED LOVEBIRD
Agapornis personatus
F: Psittacidae

Lovebirds are small African parrots that live in small flocks. Unlike most parrots, this Tanzanian species builds a nest—a domed structure in a tree cavity.

6½–7 in
17–18 cm

ROSY-FACED LOVEBIRD
Agapornis roseicollis
F: Psittacidae

This social lovebird from dry woodland and semidesert habitats of southwestern Africa habitually gathers near watering holes.

14–14½ in
35–37 cm

BROWN-NECKED PARROT
Poicephalus robustus
F: Psittacidae

The largest of a group of mainly green-gray parrots from Africa, this bird occurs in forests from Gambia to the Cape of Good Hope.

GREY PARROT
Psittacus erithacus
F: Psittacidae

A native of African rain forests, this highly intelligent species is an accomplished mimic. This has led to [illegible] the bird trade.

34 in
85 cm

BLUE-AND-YELLOW MACAW
Ara ararauna
F: Psittacidae

Macaws are large, long-tailed parrots with sparsely feathered facial patches. One of two blue and yellow species, this bird comes from northern South America.

15 in
38 cm

BLUE-FRONTED PARROT
Amazona aestiva
F: Psittacidae

A member of a large group of mostly green parrots, this species occurs in open forest habitats of central-eastern South America.

16 in
40 cm

ST VINCENT PARROT
Amazona guildingii
F: Psittacidae

Several Caribbean *Amazona* parrots are faced with extinction. This large species is being conserved by an ongoing breeding program in its native island of St. Vincent.

22–23½ in
55–60 cm

RED-FRONTED MACAW
Ara rubrogenys
F: Psittacidae

This small macaw is restricted to the arid scrub of central Bolivia. Its small population is threatened by habitat loss and wildlife trafficking.

31–35 in
79–89 cm

SCARLET MACAW
Ara macao
F: Psittacidae

Like other macaws, this noisy, flocking bird has a heavy bill for breaking nuts and palm fruit. Its range extends from southern Mexico to central Brazil.

24–28 in
9½–11 in

BLUE-HEADED PARROT
Pionus menstruus
F: Psittacidae

A relative of the *Amazona* parrots, this small parrot is common in lowland forests from Costa Rica to Bolivia.

4½–5½ in
12–14 cm

PACIFIC PARROTLET
Forpus coelestis
F: Psittacidae

Parrotlets are tiny green American parrots, only New Guinean pygmy parrots are smaller. This species occurs in western Ecuador and Peru.

3¼ ft
1 m

HYACINTH MACAW
Anodorhynchus hyacinthinus
F: Psittacidae

Unlike other macaws, this giant Brazilian parrot has its facial patch reduced to an eye-ring—similar to that of the related *Aratinga* parakeets.

17½–18 in
44–46 cm

BURROWING PARAKEET
Cyanoliseus patagonus
F: Psittacidae

A Patagonian relative of macaws, this colonial breeder nests in tunnels in earth banks. It forms monogamous pair bonds, unlike most birds.

8–10 in
20–25 cm

YELLOW-CHEVRONED PARAKEET
Brotogeris chiriri
F: Psittacidae

Native to central South America, escaped cagebirds of this species have established feral populations in warmer parts of the USA.

12 in
30 cm

JANDAYA PARAKEET
Aratinga jandaya
F: Psittacidae

Aratinga is a genus of predominantly green "mini-macaws" found in northeastern Brazil. Some have extensive splashes of golden coloration.

14½ in
29 cm

MONK PARAKEET
Myiopsitta monachus
F: Psittacidae

This colonial breeder from temperate South America is the only parrot to build a stick nest, often a large communal structure.

10 in
25 cm

MAROON-BELLIED PARAKEET
Pyrrhura frontalis
F: Psittacidae

Relatives of *Aratinga*, most *Pyrrhura* parakeets have prominent splashes of maroon or red, such as this species from eastern South America.

CUCKOOS, HOATZIN, AND TURACOS

This order includes cuckoos, mostly softly feathered birds drably colored in browns and grays, as well as the enigmatic hoatzin and the striking colored turacos.

All members of the Cuculiformes have feet with two toes pointing forward and two backward. The most primitive cuckoos are anis, heavy-bodied American birds that forage on or near the ground—a lifestyle taken to the extreme by the sprinting roadrunners. In spite of their reputation, not all cuckoos lay their eggs in other birds' nests. Almost all these ground cuckoos build nests and raise their own young, as do their Old World counterparts, such as the tropical coucals and couas. Cuckoos that lay eggs in nests of other bird species are called "brood parasites." Remarkably, this habit has evolved independently at least twice in Old World cuckoos. The chicks of crested cuckoos (*Clamator* sp.) outgrow their host nest so quickly that host chicks die from starvation. Another line of cuckoos, which includes the Eurasian common cuckoo, evolved chicks with more murderous intent: they actively eject host eggs and chicks.

DISTANT RELATIVES

Turacos, thought to be distantly related to the cuckoos, are fruit-eaters confined to Africa. They share several features with the cuckoos, including foot structure. Even more uncertainly related is the hoatzin, an enigmatic South American bird that has an entirely vegetarian diet of leaves.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	CUCULIFORMES
FAMILIES	3
SPECIES	170

DEBATE

HOATZIN: BIRD ENIGMA

Some features of the hoatzin, such as strong feet, are those of gamebirds. But the hoatzin also shares features with cuckoos, a relationship that appeared to be confirmed by early DNA studies. Later research has thrown doubt on this—leaving the hoatzin in a group of its own.

HOATZIN
Opisthocomus hoazin
F: Opisthocomidae
Of uncertain taxonomic affiliation, the hoatzin is a plant-eater of South American riverine forests. The claws on chicks' wings enable them to clamber through branches.

24–26 in
61–66 cm

spiky crest

long neck

ROSS'S TURACO
Musophaga rossae
F: Musophagidae
The second-largest turaco, this species is distinguished by its upright, red crest. It is an eastern African counterpart of the violet turaco.

20–21½ in
51–54 cm

18–20 in
45–50 cm

VIOLET TURACO
Musophaga violacea
F: Musophagidae
One of two glossy, violet-colored turacos, this species ranges through forests of western and central Africa.

long tail

fanlike crest

28–30 in
70–75 cm

yellow bill with red tip

18½–20 in
47–50 cm

19 in
48 cm

blue body

20 in
50 cm

BARE-FACED GO-AWAY BIRD
Corythaixoides personatus
F: Musophagidae
Like other go-away birds, this eastern African species is found in savanna woodland. It raises its crest when excited.

GREY GO-AWAY BIRD
Corythaixoides concolor
F: Musophagidae
Named after its call, "kay-waaay," this southern African species is a typical [illegible]

long, broad tail

GREAT BLUE TURACO
Corythaeola cristata
F: Musophagidae
This fan-crested turaco from western and central Africa is the largest and most distinctive member of the turaco family.

EASTERN GREY PLANTAIN-EATER
Crinifer zonurus
F: Musophagidae
Like the related go-away birds, plantain-eaters are drably colored. Despite their name, they favor figs not plantains. This species is from eastern Africa.

RUSPOLI'S TURACO
Tauraco ruspoli
F: Musophagidae

A distinctively white-crested green turaco, this species has one of the most restricted ranges of any turaco, being confined to forests in southern Ethiopia.

16 in
40 cm

RED-CRESTED TURACO
Tauraco erythrolophus
F: Musophagidae

This Angolan bird is one of a few turaco species with a red crest. The red color is attributed to a pigment possibly unique to turacos.

16–17 in
40–43 cm

red crest

white face

bright crimson flight feathers

17 in
43 cm

HARTLAUB'S TURACO
Tauraco hartlaubi
F: Musophagidae

A blue-crested member of the green turaco group, this species is found in highland forest in eastern Africa.

16–17 in
40–43 cm

18–18½ in
45–47 cm

GREEN TURACO
Tauraco persa
F: Musophagidae

With a range from Senegal to Angola, this is the most widespread of a group of green turacos with crimson wing feathers visible in flight.

KNYSNA TURACO
Tauraco corythaix
F: Musophagidae

A South African relative of the green turaco, this species shares the white eye-stripes, but differs in having a white-tipped crest.

JACOBIN CUCKOO
Clamator jacobinus
F: Cuculidae

Clamator cuckoos are large crested Old World cuckoos. Like others, this tropical species from Africa and Asia eats hairy caterpillars that are avoided by competitors.

13½ in
34 cm

14–16 in
35–40 cm

GREAT SPOTTED CUCKOO
Clamator glandarius
F: Cuculidae

With a range from Europe to Africa, this cuckoo lays eggs in magpie nests, but, like other *Clamator* species, does not evict the host's young.

6¾–7 in
16–18 cm

KLAAS'S CUCKOO
Chrysococcyx klaas
F: Cuculidae

This small African cuckoo is a close relative of the dideric cuckoo, differing in being greener and lacking white wing spots.

6¾–7½ in
17–19 cm

DIDERIC CUCKOO
Chrysococcyx caprius
F: Cuculidae

An African member of a group of small bronze-sheened tropical cuckoos, this species lays its eggs in weaver bird nests.

9½–11 in
24–28 cm

FAN-TAILED CUCKOO
Cacomantis flabelliformis
F: Cuculidae

This brown-breasted cuckoo of Australasian woodlands is one of very few cuckoos that are found in the Pacific—and the only one in Fiji.

9 in
23 cm

BRUSH CUCKOO
Cacomantis variolosus
F: Cuculidae

Related to Asian brown-breasted cuckoos, this plain-colored species breeds in southern Asia. The montane populations migrate to warm lowlands in winter.

11–13½ in
28–34 cm

thick, black bars on belly

HIMALAYAN CUCKOO
Cuculus saturatus
F: Cuculidae

This species from Asia and Australia is typical of a group of Old World barred cuckoos that resemble sparrowhawks—which may help them flush hosts from nests.

9½ in
24 cm

GREY-BELLIED CUCKOO
Cacomantis passerinus
F: Cuculidae

Found from the Malay Peninsula to Australia, this bird is one of many Indo-Pacific, brown-breasted species that are closely related to *Cuculus* cuckoos.

12–13 in
30–33 cm

long wings

PALLID CUCKOO
Cuculus pallidus
F: Cuculidae

Many Old World cuckoos have barred plumage, but in some, such as this Australian species, the barring occurs only in immature birds.

12–13½ in
32–34 cm

COMMON CUCKOO
Cuculus canorus
F: Cuculidae

This widespread Eurasian species overwinters in Africa and southern Asia. It has the well-known "cooc-coo" call that gives cuckoos their name.

»

» CUCKOOS, HOATZIN, AND TURACOS

10–12½ in
26–32 cm

YELLOW-BILLED CUCKOO
Coccyzus americanus
F: Cuculidae

One of several American tree cuckoos with brown plumage and white-spotted tails, this species migrates between North and South America.

15 in
38 cm

BLACK-BELLIED CUCKOO
Piaya melanogaster
F: Cuculidae

Like other American tree cuckoos, this species builds its own nest and cares for its young. It is found from Colombia to Bolivia.

24 in
62 cm

GIANT COUA
Coua gigas
F: Cuculidae

Couas are Madagascan ground-cuckoos with blue facial skin and long eyelashes. This bird lives in dry coastal forests.

13½ in
34 cm

GUIRA CUCKOO
Guira guira
F: Cuculidae

This shaggy-looking bird belongs to the ani group of S. American cuckoos. It occurs in noisy flocks and nests communally in trees.

19–20½ in
48–52 cm

GREATER COUCAL
Centropus sinensis
F: Cuculidae

Like other coucals, this southern Asian species is a strong-legged bird with spurred feet and long hind claws.

rufous head crest

11 in
28 cm

14 in
36 cm

PHEASANT-CUCKOO
Dromococcyx phasianellus
F: Cuculidae

This American ground cuckoo inhabits the forest floor in tropical South America, where it lays its eggs in the nests of smaller passerines.

streaked, reddish brown wings

23½–32 in
60–80 cm

PHEASANT-COUCAL
Centropus phasianinus
F: Cuculidae

Parental care in coucals is provided mostly by the males. This Australasian species has a black body when breeding, and builds a cup-shaped nest in grass.

long tail

PAVONINE CUCKOO
Dromococcyx pavoninus
F: Cuculidae

A smaller relative of the pheasant-cuckoo, this tropical S. American bird is a ground predator. It feeds on invertebrates.

long, graduated tail

GROOVE-BILLED ANI
Crotophaga sulcirostris
F: Cuculidae

A heavy-billed American cuckoo occurring from California to Argentina, the communal-nesting ani is a clumsy flier but runs well.

13 in
33 cm

white cheek stripe

gray-brown upperparts with white spots

♀

15½–18 in
39–46 cm

COMMON KOEL
Eudynamys scolopaceus
F: Cuculidae

Unlike most cuckoos, this tropical brood parasite, found from Asia to Australasia, is a fruit-eater. Males are black and females are gray-brown.

22 in
56 cm

GREATER ROADRUNNER
Geococcyx californianus
F: Cuculidae

This fast-running predator is an American ground cuckoo. The roadrunner inhabits deserts and nests in cacti in the southern USA and Mexico.

26–27 in
65–68 cm

CORAL-BILLED GROUND CUCKOO
Carpococcyx renauldi
F: Cuculidae

One of three species of Asian ground cuckoos related to Madagascan couas, this bird inhabits rain forests of Southeast Asia.

OWLS

With acute senses, powerful weaponry, and noiseless flight, owls are superbly adapted as nighttime hunters. Only a few species are active by day.

Although not related to birds of prey, owls, which belong to the order Strigiformes, are similarly equipped with hooked bills and strong talons. Most species have cryptic plumage for camouflage when roosting during the day. Barn owls are distinct in having heart-shaped facial disks; owls with round facial disks are more typical, although they are a family of great diversity, ranging from hawklike owlets to massive eagle owls.

SIGHT AND HEARING

All owls have large, forward-facing eyes that are efficient at letting in light and allow the birds to see well in dim conditions. Their binocular vision is good for judging distance during attacks, but they are fixed in their sockets. To track moving prey, an owl must turn its whole head. The bird can do this through a wide range of movement by means of a long flexible neck concealed beneath the plumage. Owls also have highly sensitive hearing, helped by the facial disk, which serves to guide sounds to the large ear openings. A downward-pointing bill minimizes interference with sound. An owl can determine the direction of prey with great accuracy from sounds. Most of the nocturnal species have one ear slightly higher than the other, an arrangement that helps them pick up sounds in a vertical direction, too.

SILENT HUNTERS

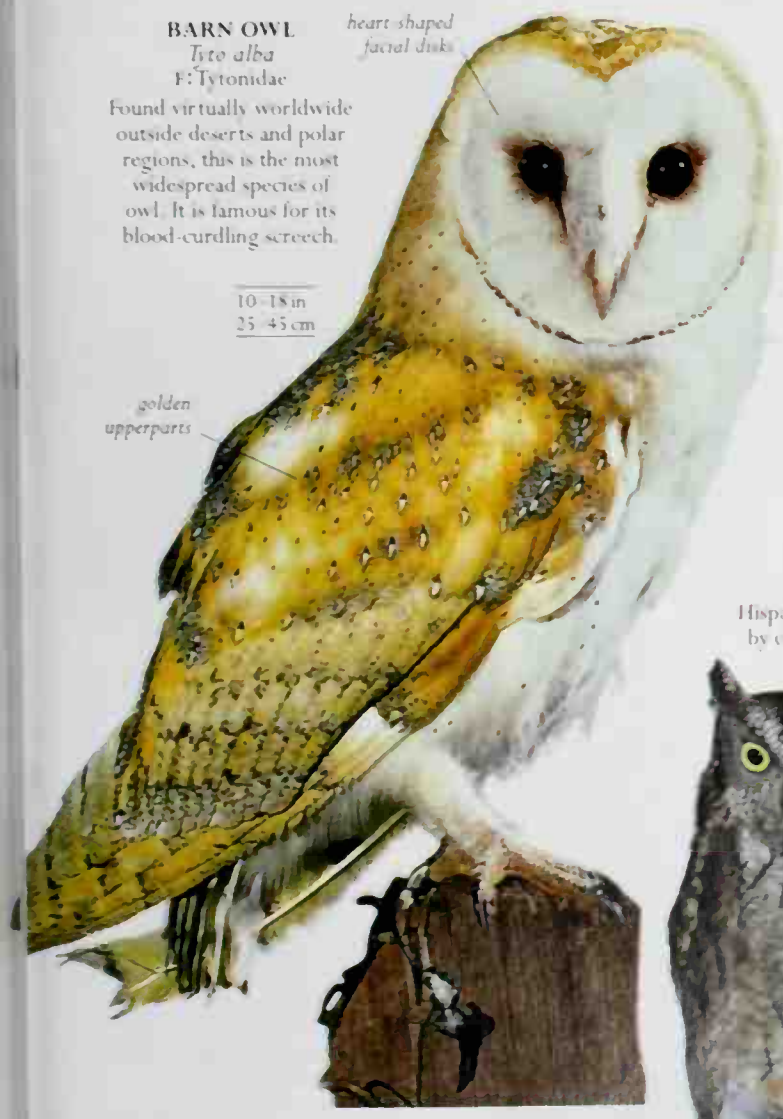
Hunting owls usually swoop down on their prey and extend their feet to make the grab. The approach is almost silent on large rounded wings that require minimal flapping. A soft fringe of serrated flight feathers breaks up air turbulence, muffling the sound of wing beats. Some day-flying species lack these fringed feathers. Most owls prey on small mammals such as mice and voles, but some of the smaller species take large insects, and a few owls are specialized fish-eaters. An owl tears larger carcasses apart with its hooked bill, but swallows smaller prey whole. The indigestible parts of a meal, such as bones and fur, are compressed in part of the stomach and later regurgitated in the form of a pellet.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	STRIGIFORMES
FAMILIES	2
SPECIES	202

DEBATE

SCREECH OWLS

There are over 60 species of owls in the genus *Otus*. In their native forests, these small, cryptically patterned birds are most reliably identified by their call. Although individual species' calls differ in frequency and duration of notes, *Otus* owls fall into two well-defined groups: scops owls, from the Old World, which call with slow notes; and American screech owls, which have faster, piercing trills. The distinction is enough for some ornithologists to advocate placing the screech owls in their own genus, *Megascops*. Recent research shows that this division may be underpinned by differences in DNA.



BARN OWL
Tyto alba
F: Tytonidae
Found virtually worldwide outside deserts and polar regions, this is the most widespread species of owl. It is famous for its blood-curdling screech.
10–18 in
25–45 cm

ASHY-FACED OWL
Tyto glaucops
F: Tytonidae
Confined to the Caribbean island of Hispaniola, this owl of dry forest is threatened by competition from the stronger barn owl.
10–17 in
26–43 cm

EURASIAN SCOPS OWL
Otus scops
F: Strigidae
This small, agile owl from western Eurasia is a typical tufted scops owl of the Old World. It nests in cavities of trees or buildings.
7½–8 in
19–20 cm

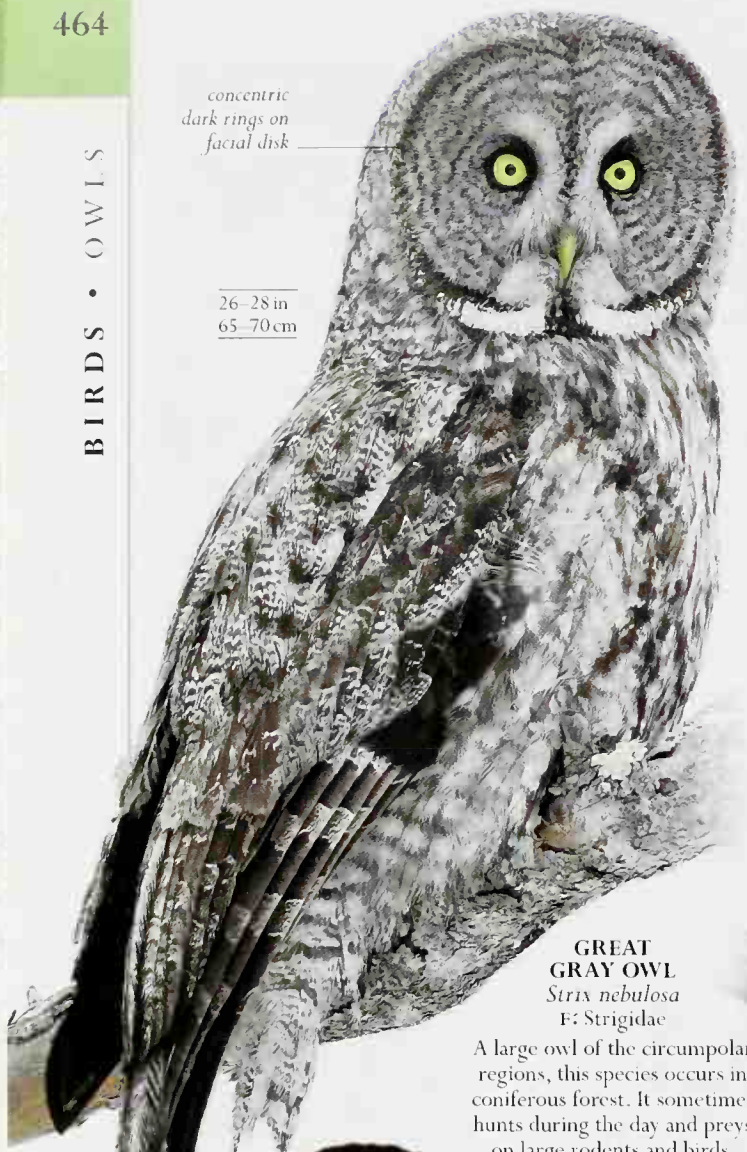
RAIN FOREST SCOPS OWL
Otus rutilus
F: Strigidae
Restricted to Madagascar, this owl is common in wooded areas. Most are gray; the rarer rufous (reddish) birds are confined to rain forests.
9–9½ in
22–24 cm

WESTERN SCREECH OWL
Otus kennicottii
F: Strigidae
A common owl of western North America, this species favors wooded areas near rivers but will also enter parkland and towns.
7½–10 in
19–25 cm

EASTERN SCREECH OWL
Otus asio
F: Strigidae
Widespread throughout eastern North America, this owl occurs in gray or rufous (reddish) color varieties, with more rufous birds farther east in its range.
6½–10 in
16–25 cm

»

» OWLS



GREAT GRAY OWL
Strix nebulosa
F: Strigidae

A large owl of the circumpolar regions, this species occurs in coniferous forest. It sometimes hunts during the day and preys on large rodents and birds.

BROWN WOOD OWL
Strix leptogrammica
F: Strigidae

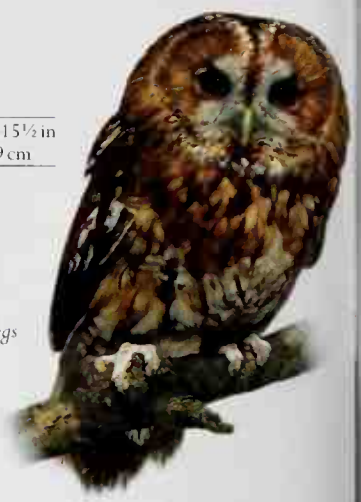
This owl occurs in lowland tropical forests throughout India and southeast Asia. Difficult to see, this wood owl can be recognized by its distinctive call.

BARRED OWL
Strix varia
F: Strigidae

A large wood owl native to eastern North America, this aggressive species is spreading westward and displacing the smaller spotted owl.

URAL OWL
Strix uralensis
F: Strigidae

A relative of the great gray owl, this north Eurasian species frequents coniferous and broadleaf forests, and may also enter towns.



TAWNY OWL
Strix aluco
F: Strigidae

Occurring throughout Eurasia, the tawny owl frequents farmland, towns, and gardens. It belongs to a group of related wood owls.

SPOTTED OWL
Strix occidentalis
F: Strigidae

Native to western North America, this wood owl occurs in mature coniferous forest, where it hunts flying squirrels and similar-sized prey.

DESERT EAGLE-OWL
Bubo ascalaphus
F: Strigidae

A bird of the Sahara Desert, this species is a smaller, paler, and longer-legged relative of the Eurasian eagle-owl.

EURASIAN EAGLE-OWL
Bubo bubo
F: Strigidae

One of the largest species of owls, this widespread eagle-owl occurs throughout Eurasia, and hunts animals as large as deer.

RUFESCENT SCREECH OWL
Otus ingens
F: Strigidae

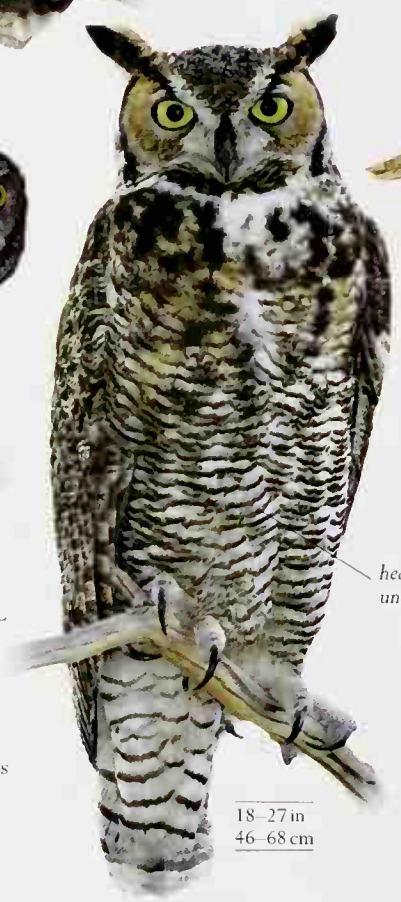
This little-known bird from wet montane forests in northern South America is one of the larger screech owls, but has smaller ears.

TROPICAL SCREECH OWL
Otus choliba
F: Strigidae

The most widespread tropical American screech owl, this species occurs in a range from Costa Rica to Argentina. It exists in brown and gray forms.

BLACK-CAPPED SCREECH OWL
Otus atricapilla
F: Strigidae

Screech owls have diversified in forests throughout the Americas. Many have conspicuous ear tufts. This species is confined to central and southern Brazil.



GREAT HORNED OWL
Bubo virginianus
F: Strigidae

The most widespread American owl, this eagle-owl is found from Alaska to Argentina, in habitats as diverse as forest and desert.

VERREAUX'S EAGLE-OWL
Bubo lacteus
F: Strigidae

This is the largest African owl. It is widespread south of the Sahara Desert, where it feeds on small game animals.

9–9½ in
22–24 cm

SOUTHERN WHITE-FACED OWL
Ptilopsis granti
F: Strigidae

Like many other owl species, this bird of sub-Saharan Africa breeds in the stick nests of other birds.

14 in
36 cm

STRIPED OWL
Pseudoscops clamator
F: Strigidae

A South American eared owl, this species lives in open, marshy habitats and nests in ground vegetation or low tree holes.

14–18 in
36–45 cm

NORTHERN HAWK-OWL
Surnia ulula
F: Strigidae

This relative of pygmy owls is found in subarctic forests. With its small head, long tail, and daytime activity, it is the most hawk-like owl.

5–6 in
13–15 cm

ELF OWL
Micrathene whitneyi
F: Strigidae

Like other insect eaters, this tiny Mexican desert owl does not need to fly silently, so it lacks the fringed, sound-muffling wing feathers of larger species.

18–18½ in
46–47 cm

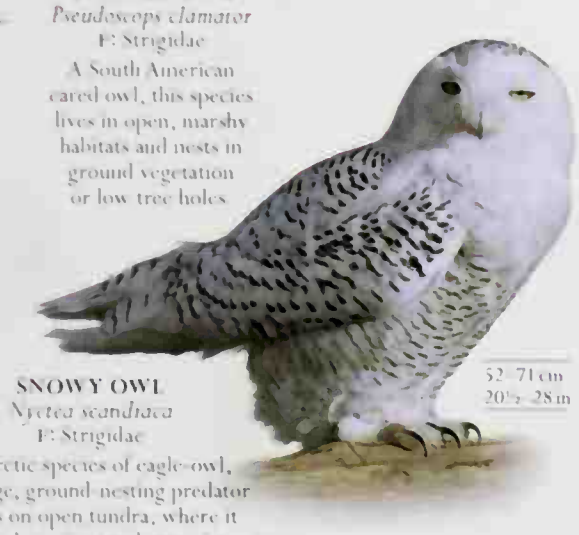
BUFFY FISH OWL
Ketupa ketupa
F: Strigidae

This southeast Asian relative of eagle-owls catches fish and other aquatic prey with the help of its long-clawed feet.

18 in
46 cm

SPECTACLED OWL
Pulsatrix perspicillata
F: Strigidae

This is a distinctive species from Central and South American forests. Its fledglings are white with a contrasting black face.



52–71 cm
20½–28 in

SNOWY OWL
Nyctea scandiaca
F: Strigidae

An Arctic species of eagle-owl, this large, ground-nesting predator breeds on open tundra, where it feeds on lemmings and ptarmigan.

5–6 in
13–15 cm

LEAST PYGMY OWL
Glaucidium minutissimum
F: Strigidae

Like other related small owls, this woodland bird of Paraguay and southeastern Brazil is active during the day and night.

6–6½ in
15–17 cm

NORTHERN PYGMY OWL
Glaucidium gnoma
F: Strigidae

Pygmy owls often fearlessly tackle prey bigger than themselves. This little predator from western North America has been seen attacking grouse.

6–7 in
15–18 cm

CUBAN PYGMY OWL
Glaucidium siju
F: Strigidae

Many owls nest in decayed tree cavities, but pygmy owls habitually choose old woodpecker holes. This species is restricted to Cuba.

6½–7 in
17–18 cm

FERRUGINOUS PYGMY OWL
Glaucidium brasilianum
F: Strigidae

Typical of pygmy owls, this American species has eyespots on the back of the head to confuse predators. It flicks its tail when excited.

»

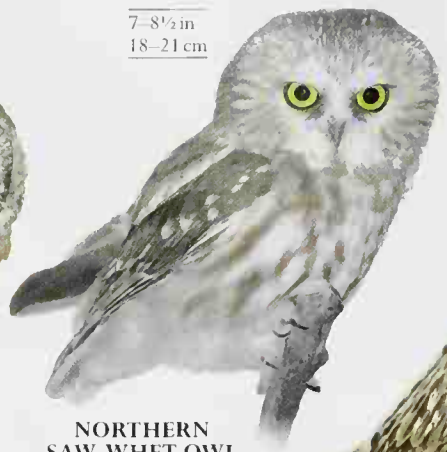
» OWLS

8½–11 in
21–28 cm

TENGMALM'S OWL
Aegolius funereus
F: Strigidae

This owl of northern circumpolar forests is adept at locating small mammals under snow. It hunts during daylight.

7–8½ in
18–21 cm



NORTHERN SAW-WHET OWL
Aegolius acadicus
F: Strigidae

A close relative of the Tengmalm's owl, this species is restricted to North America, where it primarily hunts small rodents.

13½–17 in
34–43 cm

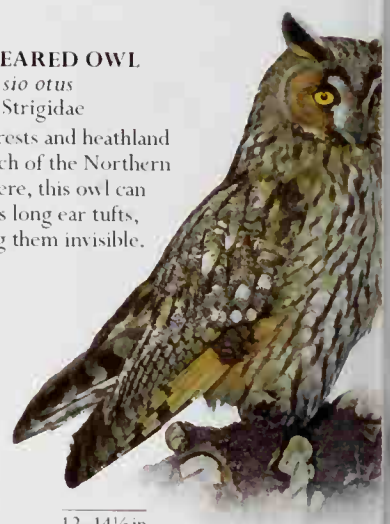
yellow eye

LONG-EARED OWL
Asio otus
F: Strigidae

Found in forests and heathland through much of the Northern Hemisphere, this owl can flatten its long ear tufts, rendering them invisible.

SHORT-EARED OWL
Asio flammeus
F: Strigidae

This owl is found in open country in a range that includes the Americas, Eurasia, and North Africa, and is even found on many Pacific islands.



12–14½ in
31–37 cm

8½–10½ in
21–27 cm

LITTLE OWL
Athene noctua
F: Strigidae

Widespread in Eurasia and North Africa, this partly diurnal predator of invertebrates and small vertebrates occurs in open woodland, farmland, and semideserts.

7½–10 in
19–25 cm

BURROWING OWL
Athene cunicularia
F: Strigidae

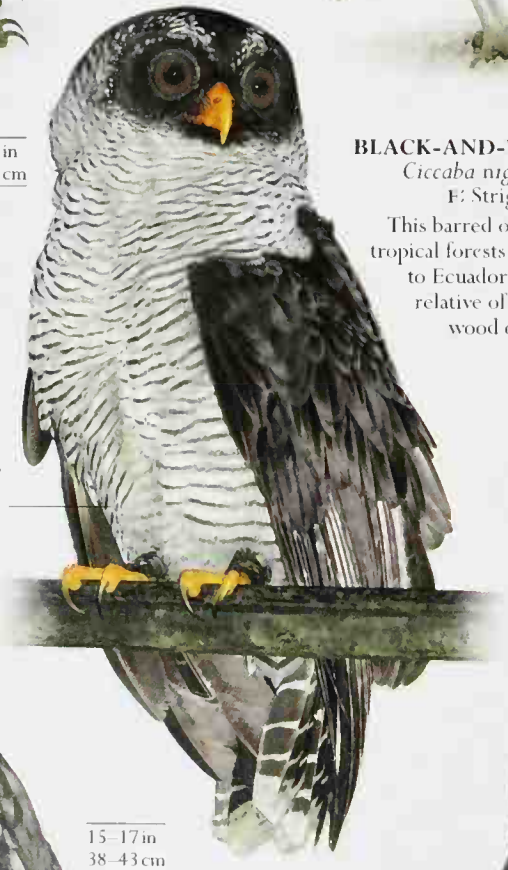
A long-legged owl, this partly diurnal species inhabits grassland and deserts across the Americas, nesting in burrows of prairie dogs or other animals.

pale brown, heart-shaped face

yellow eye

heavily streaked upperparts

15 in
38 cm



BLACK-AND-WHITE OWL
Ciccaba nigrolineata
F: Strigidae

This barred owl of dense tropical forests from Mexico to Ecuador is a close relative of the *Strix* wood owls.

barred underparts

15–17 in
38–43 cm

BARKING OWL
Ninox connivens
F: Strigidae

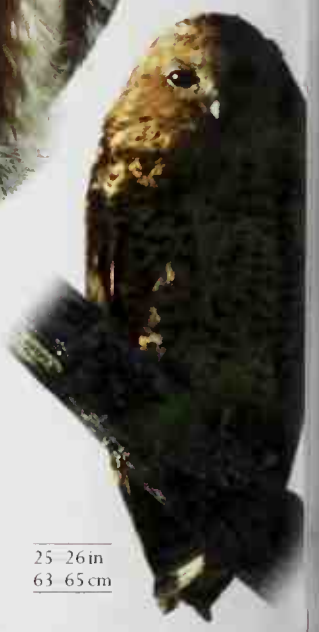
Found from the Moluccas, Indonesia, to Australia, this woodland hawk-owl is named for its doglike barking call.

12–14 in
30–35 cm

MOREPORK
Ninox novaeseelandiae
F: Strigidae

Typical of Australasian hawk-owls, this bird has large, yellow eyes. Unlike most owls, the male of the species is larger than the female.

25–26 in
63–65 cm



PEL'S FISHING OWL
Scotopelia peli
F: Strigidae

The largest African fishing owl, this bird frequents riverside forest, where it hunts from low perches in slow-running waters. It eats mainly fishes, but also crabs and frogs.

NIGHTJARS AND FROGMOUTHS

All nightjars and their relatives are nocturnal. Most are insect-eaters, snatching their prey on the wing using an exceptionally wide bill gape.

Voracious predators by night, concealed by cryptic plumage during the day, nightjars have similarities to owls, and some ornithologists have thought the two groups to be related. Recent studies, however, link nightjars with swifts and hummingbirds. The connection is supported by features such as the weakness of their feet and the ability of some species to enter a torpid state.

Nightjars belong to the order Caprimulgiformes. Typically, they have big heads and long wings for quick aerial maneuvers. Their short bills open amazingly wide to catch flying insects. The gape is particularly wide in the aptly named frogmouths from Australasia, which are predators of small vertebrates. Of the group, only the oilbird is vegetarian: a fruit-eater that roosts by day in caves.

All these birds are masters of camouflage. Nightjars blend perfectly with forest litter when on the ground; in trees they perch lengthways on a branch to minimize detection. Frogmouths and potoos freeze when disturbed, to mimic tree stumps, closing their eyes to complete the effect.

MINIMAL NESTS

All in this group are minimalist nesters. Nightjars simply lay their eggs in leaf litter on the ground. For oilbirds, a nest is a pile of droppings on a cave ledge, while potoos use nothing more than a depression on a branch.

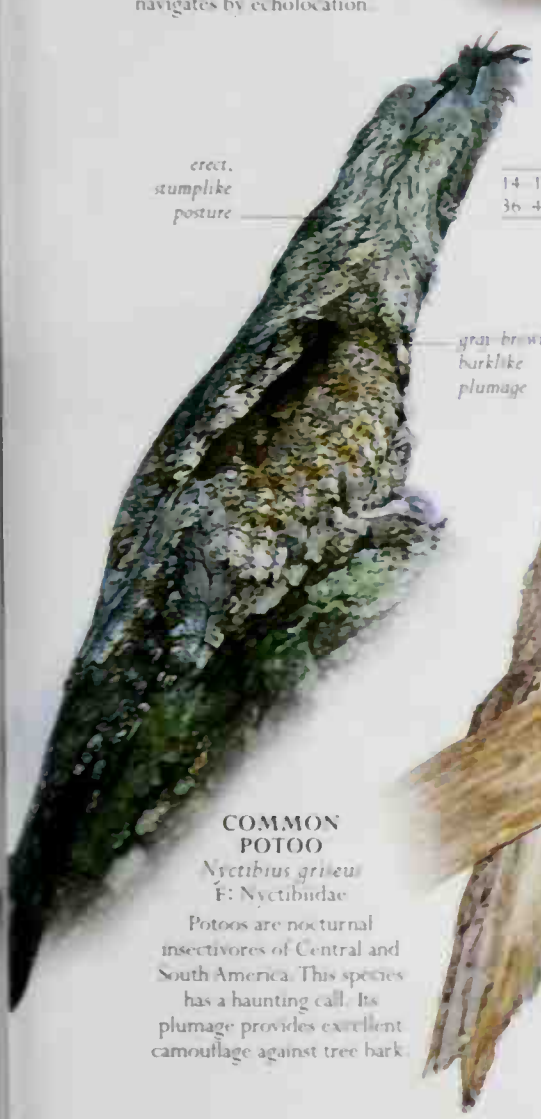
PHYLUM	CHORDATA
CLASS	AVES
ORDER	CAPRIMULGIFORMES
FAMILIES	5
SPECIES	125

A great potoo opens its enormous gape, displaying a key feature of a group of birds that can scoop up flying insects on the wing.

16–19 in
41–48 cm

OILBIRD
Steatornis caripensis
F: Steatornithidae

A fruit-eating relative of nightjars, this cave-nesting species from northern South America is the only nocturnal bird that navigates by echolocation.



14–16 in
36–41 cm

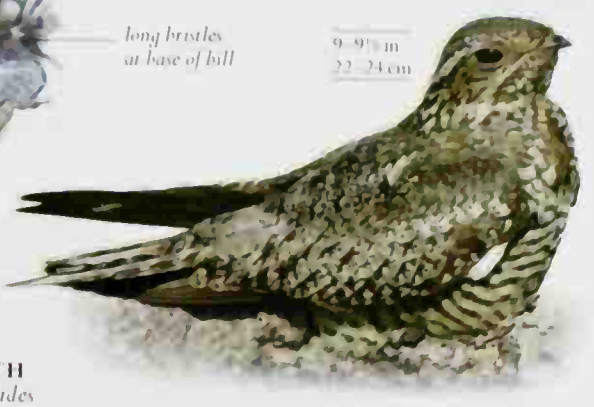
COMMON POTOO
Nyctibius griseus
F: Nyctibiidae

Potoos are nocturnal insectivores of Central and South America. This species has a haunting call. Its plumage provides excellent camouflage against tree bark.

12½–18 in
32–46 cm

TAWNY FROGMOUTH
Podargus strigoides
F: Podargidae

This nocturnal Australian bird hunts from perches. Like other frogmouths, it roosts motionless during the day, resembling a broken branch.



9–9½ in
22–24 cm

COMMON NIGHTHAWK
Chordeiles minor
F: Caprimulgidae

Nighthawks lack the bill bristles of nightjars, and this absence perhaps helps in their aerial pursuit of insects. This insect-eater migrates between North and South America.

8 in
20 cm

OCELLATED POORWILL
Nyctiphrynus ocellatus
F: Caprimulgidae

Poorwills are small American nightjars, so called because of their mournful, monotonous calls. This dark-colored species occurs in tropical forests.

7½–8½ in
19–21 cm

COMMON POORWILL
Phalaenoptilus nuttallii
F: Caprimulgidae

From arid parts of the USA and Mexico, this small nightjar is one of the few birds that enters a hibernation-like torpor in winter.

9–11 in
24–28 cm

COMMON PAURAQUE
Nyctidromus albicollis
F: Caprimulgidae

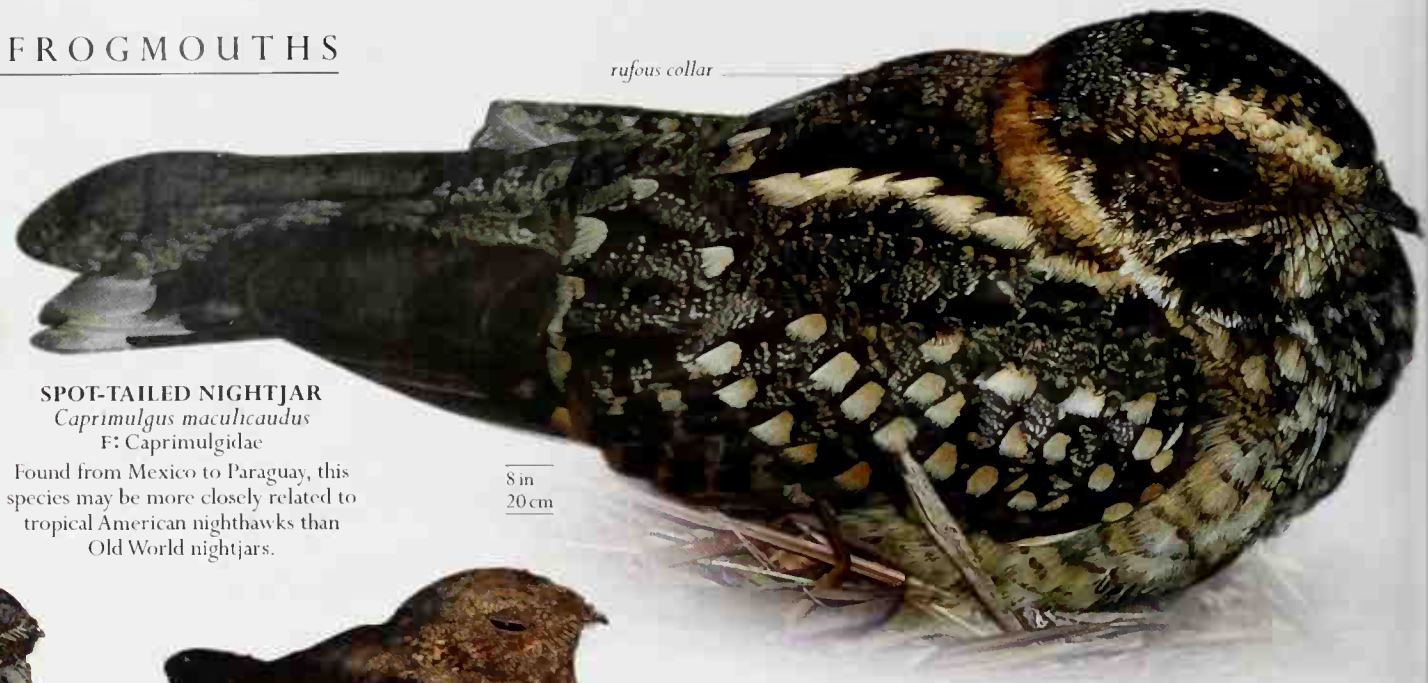
This Central and South American nighthawk frequents scrubby habitats. It is often seen resting on dirt roads at night.

»

10–11 in
26–28 cm

EUROPEAN NIGHTJAR
Caprimulgus europaeus
F: Caprimulgidae

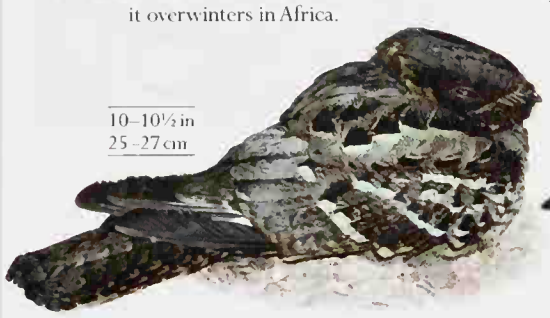
Like many nightjars of northern temperate regions, this species is migratory. Found in western Eurasian heath and woodland, it overwinters in Africa.



SPOT-TAILED NIGHTJAR
Caprimulgus maculicaudus
F: Caprimulgidae

Found from Mexico to Paraguay, this species may be more closely related to tropical American nighthawks than Old World nightjars.

8 in
20 cm



10–10½ in
25–27 cm

LARGE-TAILED NIGHTJAR
Caprimulgus macrurus
F: Caprimulgidae

Among the most widespread of the Old World nightjars, this species ranges from Pakistan to Australia and New Guinea.

9 in
22 cm

PLAIN NIGHTJAR
Caprimulgus inornatus
F: Caprimulgidae

This African bird occurs from Mauritania to Saudi Arabia, and migrates south to Liberia, Congo, and Tanzania.

9 in
23 cm

DUSKY NIGHTJAR
Caprimulgus saturatus
F: Caprimulgidae

Perhaps genetically closer to American poorwills than Old World nightjars, this species occurs in montane forests of Costa Rica and Panama.

10–14 in
25–35 cm

LONG-TAILED NIGHTJAR
Caprimulgus climacurus
F: Caprimulgidae

The long tail of some nightjars may be used in a courtship display. This African species has a range from Senegal to Ethiopia.

9–11 in
23–28 cm

LADDER-TAILED NIGHTJAR
Hydropsalis climacocerca
F: Caprimulgidae

This Amazonian species belongs to a group of S. American nightjars, in which males have long, forked tails with white markings. These give the bird its name and are possibly used to attract females.

MADAGASCAR NIGHTJAR
Caprimulgus madagascariensis
F: Caprimulgidae

This nightjar from Madagascar and Aldabra Island (Seychelles) has a call that resembles the sound of a marble bouncing on a hard floor.

8½ in
21 cm

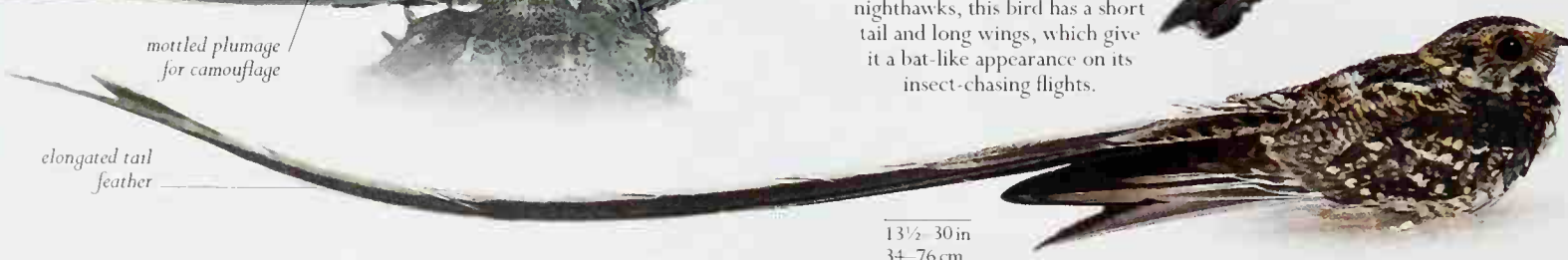
9 in
22 cm

SHORT-TAILED NIGHTHAWK
Lurocalis semitorquatus
F: Caprimulgidae

One of several tropical American nighthawks, this bird has a short tail and long wings, which give it a bat-like appearance on its insect-chasing flights.

LONG-TRAINED NIGHTJAR
Macropsalis creagra
F: Caprimulgidae

As with many nightjars, males have elaborate tails. This species, limited to eastern South America, evolved from tropical American nighthawks.



13½–30 in
34–76 cm

STANDARD-WINGED NIGHTJAR
Macrodipteryx longipennis
F: Caprimulgidae

This African species eats insects, including moths and beetles. Breeding males have flaglike flight feathers, longer than the body, that they raise in courtship displays.

8½–9 in
21–23 cm

HUMMINGBIRDS AND SWIFTS

The dashing flight of swifts—fastest of all birds—and the audible hovering of hummingbirds characterize the master aeronauts united in this order.

Both swifts and hummingbirds, members of the order Apodiformes, have tiny feet that are useful only for perching, but in compensation the birds have exceptional maneuverability on the wing. Swifts skim through the skies to catch flying insects. Hummingbirds have the wing control to fly backward, some of them whirring at over 70 wing beats per second—sustained by high metabolism fueled by energy-rich nectar. Insects and spiders provide hummingbirds with protein to feed to their chicks. Hummingbirds use cobwebs to glue together their thimble-sized nests, while swifts use saliva. The swifts' range is almost worldwide, reaching oceanic islands. Hummingbirds are found only in the Americas.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	APODIFORMES
FAMILIES	4
SPECIES	447

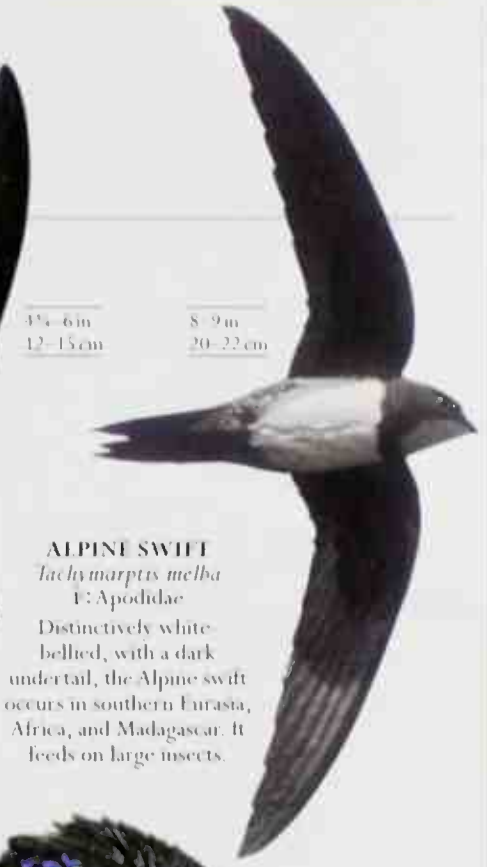
deeply forked tail

COMMON SWIFT
Apus apus
F: Apodidae
This Eurasian swift nests in holes in cliffs or buildings, making it a common bird in towns. It overwinters in Africa.

6½ in
16–17 cm

6–7 in
15–18 cm

WHITE-THROATED SWIFT
Aeronautes saxatalis
F: Apodidae
Found in canyons and mountains of western North America and Central America, this bird gathers in flocks in the evenings to roost.


3¾–6 in
12–15 cm

8–9 in
20–22 cm

CHIMNEY SWIFT
Chaetura pelagica
F: Apodidae
Originally nesting in caves and tree-holes, this eastern North American species now nests primarily in chimneys in urban centers. It winters in South America.

ALPINE SWIFT
Tachymarptis melba
F: Apodidae
Distinctively white-bellied, with a dark undertail, the Alpine swift occurs in southern Eurasia, Africa, and Madagascar. It feeds on large insects.

4¾ in
12 cm

WHITE-TIPPED SICKLEBILL
Eutoxeres aquila
F: Trochilidae
This bird has a range that extends from Costa Rica to Peru. It uses its decurved bill to feed from similarly curved *Heliconia* flowers.

4 in
10 cm

GREEN-FRONTED LANCEBILL
Doryfera ludovicae
F: Trochilidae
This inhabitant of the forests of the Andes takes nectar from five species of epiphytes (plants that grow on other plants), one of which is a mistletoe.

5 in
13 cm

SCALE-THROATED HERMIT
Phaethornis eurynome
F: Trochilidae
Hermits are dull-colored hummingbirds with long, curved bills for probing *Heliconia* flowers. This species is from eastern South America.

violet "ear" patch

4¾ in
11 cm

metallic blue throat

WHITE-VENTED VIOLET-EAR
Colibri serrirostris
F: Trochilidae
Most of the violet-eared hummingbirds occur in highland forests, but this species is native to the South American savanna.

decurved bill

violet-blue underparts

5½–6 in
14–15 cm

VIOLET SABREWING
Campylopterus hemileucurus
F: Trochilidae
Sabrewings are named for the thickened shafts of their flight feathers. This Central American bird is the largest hummingbird outside South America.

»

RUBY TOPAZ
Chrysolampis mosquitus
F: Trochilidae

This South American, open-country species has a ruby-red crown and topaz-yellow throat, but in poor light the bird can appear all black.

brown-black plumage

3½ in
9 cm

orange-red tail

3¼ in
8 cm

HOODED VISORBEARER
Augastes lumachella
F: Trochilidae

Visorbearers, with their green facial masks, are hummingbirds of arid habitats, such as highland savanna. This species occurs in eastern Brazil.

2¾ in
7 cm

BRAZILIAN RUBY
Clytolaema rubricauda
F: Trochilidae

Named for the male's rufous tail, this hummingbird is found in southeastern Brazil, but may be closely related to species found in the Andes.

2¾–3½ in
7–9 cm

RUBY-THROATED HUMMINGBIRD
Archilochus colubris
F: Trochilidae

This tiny bee hummingbird is the only hummingbird breeding in the eastern USA. It flies nonstop to the Gulf of Mexico to overwinter.

4–7 in
10–18 cm

LONG-TAILED SYLPH
Aglaiocercus kingi
F: Trochilidae

Belonging to a diverse group of Andean hummingbirds called coquettes, this bird inhabits woodland borders and gardens. Males have long, deeply forked tails.

4¼ in
11 cm

BUFF-TAILED CORONET
Boissonneaua flavescens
F: Trochilidae

Found in Colombia, Venezuela, and Ecuador, this relative of Andean hummingbirds forages near flowering trees from mid-level to forest canopy, often with other birds.

4–4¼ in
10–11 cm

BUFF-BELLIED HUMMINGBIRD
Amazilia yucatanensis
F: Trochilidae

Belonging to a large group of "emerald" hummingbirds found in Central America, this bird is a Mexican species of open woodland.

3½ in
9 cm

BLUE-CHINNED SAPPHIRE
Chlorostilbon notatus
F: Trochilidae

One of many "emerald" hummingbirds with metallic green plumage, this forest and farmland bird is from northern South America.

4¼ in
11 cm

COLLARED INCA
Coeligena torquata
F: Trochilidae

Incas form a group of forest hummingbirds native to the Andes. The collared inca is one of the most widespread of the group, found from Colombia to Bolivia.

dark ear patch

short, straight bill

3½ in
9 cm

SPECKLED HUMMINGBIRD
Adelomyia melanogenys
F: Trochilidae

A common hummingbird from the Andes, this species has duller plumage than many of its relatives in the coquette group. The sexes are similar.

BLUE-THROATED HUMMINGBIRD
Lampornis clemenciae
F: Trochilidae

This large Mexican species belongs to a group of hummingbirds called mountain gems that originated in Central America. The northerly populations are migratory.

4¾ in
12 cm

4 in
10 cm

ANNA'S HUMMINGBIRD
Calypte anna
F: Trochilidae

A bee hummingbird of western North America, this species overwinters farther north than other hummingbirds. The bird feeds on nectar from a wide range of flowers.

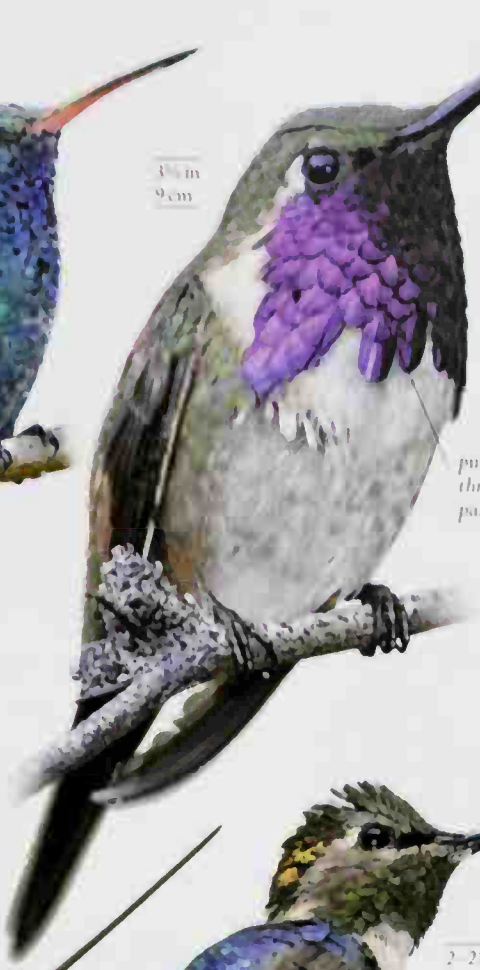
WHITE-EARED HUMMINGBIRD
Basilinna leucotis
F: Trochilidae

This "emerald" hummingbird frequents pine and oak montane forests, often near streams, from southern Arizona to Nicaragua.

3½–4 in
9–10 cm

5 in
13 cm

4 in
10 cm



3½ in
9 cm

LUCIFER HUMMINGBIRD
Calothorax lucifer
F: Trochilidae

This bee hummingbird has a range from the southern USA to Mexico. It lives in semideserts, especially those with *Agave* plants.

purple throat patch

4¾ in
12 cm

ANDEAN HILLSTAR
Oreotrochilus estella
F: Trochilidae

An Andean coquette hummingbird, this species lives higher than other species of the group, and feeds in air so thin that it cannot hover.

straight, black bill

FORK-TAILED WOODNYMPH
Thalurania furcata
F: Trochilidae

A South American relative of the Central American "emerald" hummingbirds, this species occurs in lowland forests as far south as northern Argentina.

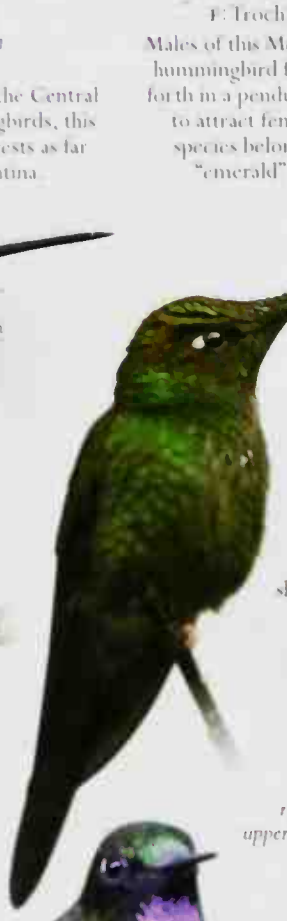
BROAD-BILLED HUMMINGBIRD
Cynanthus latirostris
F: Trochilidae

Males of this Mexican scrub hummingbird fly back and forth in a pendulum display to attract females. The species belongs to the "emerald" group.

4 in
10 cm

iridescent green throat

4 in
10 cm



9–10 in
23–26 cm

SWORD-BILLED HUMMINGBIRD
Ensifera ensifera
F: Trochilidae

The only bird with a bill longer than its body, this member of the Andean inca group favors the trumpet-shaped flowers of passion vines.

2–2¼ in
5–6 cm

BEE HUMMINGBIRD
Mellisuga helenae
F: Trochilidae

This tiny hummingbird is confined to Cuba, but is related to migratory North American hummingbirds. Males of the species are the smallest of all birds.

4¾ in
12 cm

RACKET-TAILED PUFFLEG
Ocreatus underwoodii
F: Trochilidae

Belonging to the inca group, this bee-sized hummingbird of Andean forests is attracted to brush blossoms, such as those of legumes.

STRIPE-BREASTED STARTHROAT
Heliomaster squamosus
F: Trochilidae

Male starthroats have a vividly colored band around their throats. Although starthroats are related to Central American mountain gems, this species is from eastern Brazil.

4¾ in
12 cm

WHITE-NECKED JACOBIN
Florisuga mellivora
F: Trochilidae

Genetic research suggests that this large, canopy-dwelling bird of tropical American lowlands belongs to a small lineage independent of other groups in its family.

3½ in
9 cm

GORGETED SUNANGEL
Heliangelus strophianus
F: Trochilidae

Sunangels belong to the coquette group of Andean hummingbirds. This species is found from Colombia to Ecuador and lives in wet forest thickets.

white spot near the eye

2¾–3½ in
7–9 cm

rufous upperparts

RUFOUS HUMMINGBIRD
Selasphorus rufus
F: Trochilidae

Sustaining the longest migration of comparably small birds, this aggressively territorial bee hummingbird takes a route from Alaska to Mexico.

3½ in
9 cm

CALLIOPE HUMMINGBIRD
Stellula calliope
F: Trochilidae

One of the migratory bee hummingbirds, this bird breeds in open forests of western North America and winters in the Mexican semidesert.

3½ in
9 cm

PLOVERCREST
Stephanoxis lalandi
F: Trochilidae

This distinctive bird may be related to larger sabrewings of Central America, but is found in montane forests of eastern South America.

TROGONS

Gaudily colored birds of tropical forests, the fruit-eating trogons have wide bills, delicate plumage, and a foot structure unique to this group.

Crow-sized birds belonging to the order Trogoniformes are found in tropical America, Africa, and Asia. The males have brighter plumage than the females. Long-tailed and short-winged, trogons are capable fliers, though reluctant to break cover. The first and second toes of a trogon's foot face backward whereas the third and fourth toes face forward, an arrangement seen in no other birds. These unusual feet are so weak that a trogon can barely manage more than a shuffle when it is perched.

Trogons use their wide bills for tackling large fruit and taking invertebrates such as caterpillars. They also use their bills for excavating nesting holes in rotten wood and termite mounds.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	TROGONIFORMES
FAMILIES	1
SPECIES	40

RESPLENDENT QUETZAL
Pharomachrus mocinno
F: Trogonidae
Quetzals are iridescent American trogons. The male's long tail in this Central American species is almost half its overall length.

RED-HEADED TROGON
Harpactes erythrocephalus
F: Trogonidae
An Asian trogon found from the Himalayas to Sumatra, this elusive bird, like many of its cousins, perches motionless for long periods.

ELEGANT TROGON
Trogon elegans
F: Trogonidae
The only trogon with a range that extends into the USA, this bird occurs in montane forests from southern Arizona to Central America.

ORANGE-BREASTED TROGON
Harpactes oreskios
F: Trogonidae
The color pattern of this bird, dull upperparts, and bright underparts, is typical of many Asian trogons. This species is a native of southeast Asia.

MASKED TROGON
Trogon personatus
F: Trogonidae
Males of this species from South American montane forests have plumage that resembles that of the elegant trogon.

CUBAN TROGON
Priotelus temnurus
F: Trogonidae
One of two species of *Priotelus* trogons confined to the Caribbean, this is the national bird of Cuba.

MOUSEBIRDS

Named for their scurrying, rodentlike behavior, the mousebirds are a small group of drab-colored, long-tailed birds confined to sub-Saharan Africa.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	COLIIFORMES
FAMILIES	1
SPECIES	6

Mousebirds, the sole family of the order Coliiformes, are softly feathered in shades of brown or gray and have erectile crests and long tails. Gregarious and agile, they resemble parakeets in behavior. These tree-dwelling birds build twiggy, cup-shaped nests. The chicks hatch at an advanced stage of development and quickly master flight. Ornithologists think that mousebirds are the remnant of a more diverse group that, in prehistoric times, ranged beyond Africa—fossil mousebirds have been found in Europe. Their relationship to other birds is uncertain: mousebirds could be allied with trogons, kingfishers, or woodpeckers.

SPECKLED MOUSEBIRD
Colius striatus
F: Coliidae
The largest and one of the most widespread of mousebirds, this species occurs from Nigeria to South Africa in savanna and open woodland.

BLUE-NAPED MOUSEBIRD
Urocolius macrourus
F: Coliidae
Urocolius mousebirds are stronger fliers and less "mouselike" than *Colius* mousebirds. This scrubland dweller is found from Senegal to Tanzania.

KINGFISHERS AND RELATIVES

These birds are generally sit-and-wait predators of comparatively large prey. Some, such as hornbills, eat fruit too. Most dig cavity nests in banks or trees.

This order, the Coraciiformes, has a worldwide distribution. Many species are brightly plumaged, and all have the same foot structure: they perch with three toes pointing forward, and their two outer toes are fused at the base. The three main groups of kingfishers—river, tree, and water—follow diverse lifestyles. Many kingfisher species hunt land animals, including lizards, rodents, and insects, as well as fish. Large heads and strong neck muscles help these birds dive efficiently, and their long bills are sharp edged to grip slippery prey. Other members of this order, the motmots of Central and South America and the Old World rollers, are all land hunters. Kingfisher relatives have a wide variety of bill shapes. In the aerial-hunting bee-eaters, the long bill holds stinging insects away from the head, and is used like forceps to squeeze out insect venom. Hoopoes probe the ground for grubs with their curved bills. Hornbills use their huge bills to take fruit and catch mammals, reptiles, and even other birds.

SEALED NESTS

Some male hornbills partially seal up their nesting cavities when the female is incubating. Using their bill as a spatula, they spread mud over the entrance, leaving a slit through which the temporarily imprisoned female can be fed.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	CORACIIFORMES
FAMILIES	10
SPECIES	218

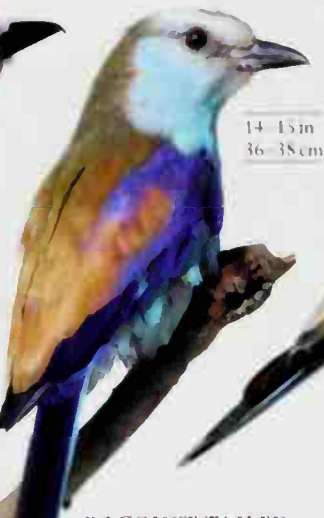
Most hornbills, such as this rhinoceros hornbill, have a hollow projection (casque) above the bill that helps to resonate calls.

LILAC-BREASTED ROLLER
Coracias caudatus
F: Coraciidae

Like other *Coracias* rollers, this African bird is a predator of ground animals, swooping to take lizards, rodents, and large invertebrates.

12½–14 in
32–36 cm

11–12 in
28–30 cm



14–15 in
36–38 cm

11½–12½ in
29–32 cm

EUROPEAN ROLLER
Coracias garrulus
F: Coraciidae

The most widespread of the *Coracias* rollers, named for their somersaulting courtship displays, this western Eurasian species overwinters in Africa.

black stripe through eye

white throat

RUFOUS-CROWNED ROLLER
Coracias naevius
F: Coraciidae

Somewhat dull colored compared with other species, this large roller inhabits arid areas across sub-Saharan Africa.

14–16 in
36–41 cm

BLUE-BELLIED ROLLER
Coracias cyanogaster
F: Coraciidae

This central African roller, like many of its relatives, nests in tree cavities. The species is common throughout its extensive range.

RACQUET-TAILED ROLLER
Coracias spatulatus
F: Coraciidae

This distinctive fork-tailed roller from East Africa has outer tail feathers that have projecting "flag-tipped" vanes.

PITTA-LIKE GROUND ROLLER
Atelornis pittoides
F: Brachypteraciidae

As the name suggests, ground rollers are mostly terrestrial. This rain forest species is the most brightly colored of the family.

10 in
26 cm

DOLLARBIRD
Eurystomus orientalis
F: Coraciidae

Named for its pale, coin-shaped underwing markings, this roller occurs in woodland from the Himalayas to Australia.

10½–12 in
27–30 cm

long, brown tail with dark barring

18½–20½ in
47–52 cm

yellow bill

10½–12 in
27–30 cm

BROAD-BILLED ROLLER
Eurystomus glaucurus
F: Coraciidae

Typical of its genus, this African species is longer winged and more agile in pursuit of flying prey than *Coracias* rollers.

LONG-TAILED GROUND ROLLER
Uratelornis chimaera
F: Brachypteraciidae

Like other ground rollers, this species from the dry forests of southwest Madagascar nests in holes excavated in the ground.

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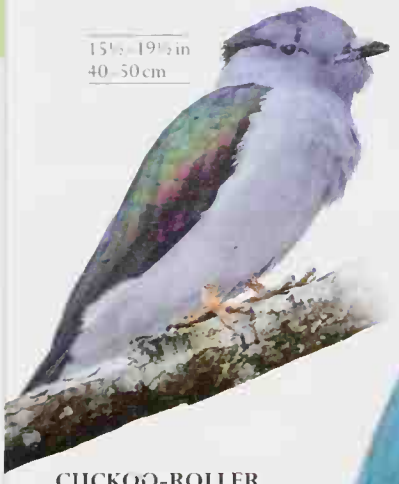
» KINGFISHERS AND RELATIVES

15½–19½ in
40–50 cm



CUCKOO-ROLLER
Leptosomus discolor
F: Leptosomatidae

Superficially resembling a cuckoo, this Madagascan predator of small animals is not closely related to true rollers. It nests in tree cavities.

bright blue back and wings

11½ in
29 cm

white throat and chest

WHITE-THROATED KINGFISHER
Halcyon smyrnensis
F: Alcedinidae

Like many other tree kingfishers, this southern Asian species is a noisy bird. It has whinnying and laughterlike calls.

8 in
20 cm

GREY-HEADED KINGFISHER
Halcyon leucocephala
F: Alcedinidae

Tree kingfishers are a group of mainly insect-eating forest birds. The grey-headed kingfisher is an African species that may also eat fishes.

dark eye patch contrasts with the white head

heavy bill

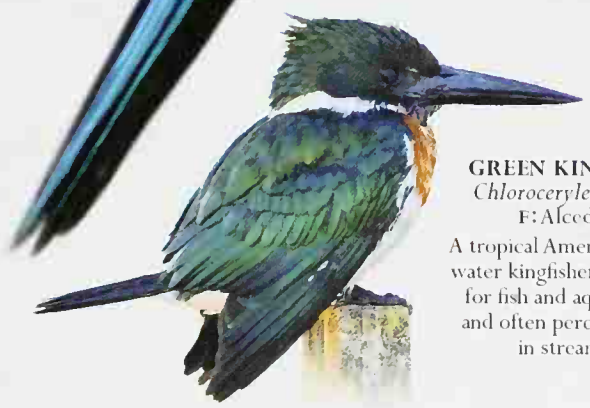
18 in
46 cm

4¾–5 in
12–13 cm

AFRICAN PYGMY KINGFISHER
Ceyx pictus
F: Alcedinidae

This African bird belongs to a group of river kingfishers, but mainly feeds on insects so it occurs away from water in woodland and savanna.

7–8 in
18–20 cm



GREEN KINGFISHER
Chloroceryle americana
F: Alcedinidae

A tropical American bird, this water kingfisher plunge-dives for fish and aquatic insects and often perches on rocks in streambeds.

LAUGHING KOOKABURRA
Dacelo novaeguineae
F: Alcedinidae

Widespread in Australian woodland, this large tree kingfisher preys on reptiles as well as invertebrates, and has a loud chuckling call.

7–8½ in
18–21 cm

YELLOW-BILLED KINGFISHER
Syma torotoro
F: Alcedinidae

This tree kingfisher occurs in rainforests of New Guinea and northern Australia. It feeds mainly on insects, but also eats worms and small lizards.

6½–7½ in
17–19 cm

azure-blue upperparts

orange underparts

AZURE KINGFISHER
Alcedo azurea
F: Alcedinidae

Like other river kingfishers, the azure kingfisher nests in holes along riverbanks. It is found in creeks and mangroves in Australia and New Guinea.

6½ in
16–17 cm

COMMON KINGFISHER
Alcedo atthis
F: Alcedinidae

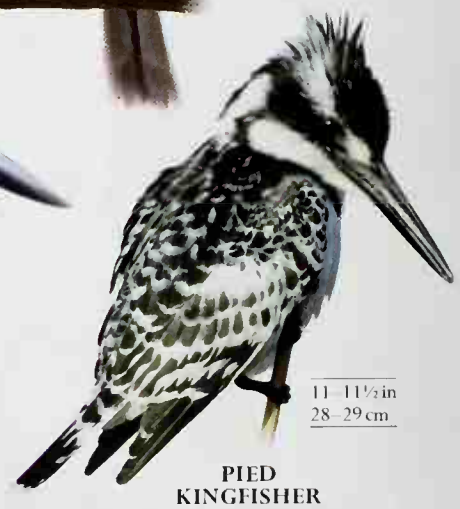
Found in Eurasia and North Africa, this bird is typical of a group of diminutive, short-tailed river kingfishers from the Old World.

4¾–5 in
12–13 cm

LITTLE KINGFISHER
Alcedo pusilla
F: Alcedinidae

This tiny Australasian species of mangroves is a river kingfisher. It eats tiny fish, insect larvae, small crustaceans, and shrimps.

11–11½ in
28–29 cm



PIED KINGFISHER
Ceryle rudis
F: Alcedinidae

From Africa and southern Asia, this water kingfisher of rivers and lakes often gathers in small groups. It can hover in one spot for long periods of time.

single blue chest band

11–14 in
28–35 cm

BELTED KINGFISHER
Megaceryle alcyon
F: Alcedinidae

A water kingfisher from North America, the belted kingfisher is a fishing specialist that often hovers over water before diving for prey.

12–14 in
30–35 cm

BUFF-BREASTED PARADISE KINGFISHER
Tanysiptera sylvia
F: Alcedinidae

Many tree kingfishers, such as this species from New Guinea and northern Australia, nest in holes in tree-top termite mounds.

14½ in
37 cm

BROWN-WINGED KINGFISHER
Pelargopsis amauroptera
F: Alcedinidae

A tree kingfisher of mangrove forests, this species occupies a range from India to the Malay Peninsula.

14½–16 in
37–41 cm

STORK-BILLED KINGFISHER
Pelargopsis capensis
F: Alcedinidae

Occurring in southern Asia, this bird is found near water in forests, especially outside the range of the related brown-winged kingfisher.

10–11 in
25–28 cm

COLLARED KINGFISHER
Todiramphus chloris
F: Alcedinidae

Preferring mangroves, this tree kingfisher is widespread in coastal areas across southern Asia to the Pacific.

white central tail feathers

8½–9½ in
22–24 cm

WHITE-FRONTED BEE-EATER
Merops bullockoides
F: Meropidae

This African bee-eater breeds in large colonies, which have a complex social system with nonbreeding birds assisting in raising the young.

8½–10 in
22–25 cm

GREEN BEE-EATER
Merops orientalis
F: Meropidae

Found in dry, open habitats in Africa and southern Asia, the green bee-eater nests in looser colonies than other species of bee-eater.

black eye-stripe

long, slightly curved bill

10–11½ in
25–29 cm

EUROPEAN BEE-EATER
Merops apiaster
F: Meropidae

Like other bee-eaters, this bird from southwestern Eurasia and Africa catches insects in flight. Before eating bees, it removes the sting from its prey.

9 in
23 cm

RAINBOW BEE-EATER
Merops ornatus
F: Meropidae

The only bee-eater in Australia, southernmost populations of this species migrate northward to overwinter in northern Australia and Indonesia.

8–12½ in
20–32 cm

WHITE-THROATED BEE-EATER
Merops albicollis
F: Meropidae

Occurring in Africa south of the Sahara, like other bee-eaters, the white-throated bee-eater nests in tunnels in sand banks.

turquoise-blue crown

18 in
46 cm

RUFOUS MOTMOT
Baryphthengus martii
F: Momotidae

Like other motmots, this stout-billed bird from C. and northern S. America sallies for large insects and small vertebrates.

13 in
33 cm

TURQUOISE-BROWED MOTMOT
Eumomota superciliosa
F: Momotidae

As with other motmots, the racket-tipped tail of this Central American motmot is formed by weakened feather barbs that break away.

racketlike tail tip

16 in
41 cm

BLUE-CROWNED MOTMOT
Momotus momota
F: Momotidae

Like the related bee-eaters and many kingfishers, this typical brightly colored motmot from tropical America nests in tunnels in riverbanks.

4½ in
11 cm

JAMAICAN TODY
Todus todus
F: Todidae

Todies are tiny, green kingfisher-like birds from the Caribbean, with flattened bills for catching insects in flight. This species is found only in the woodlands of Jamaica.

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» KINGFISHERS AND RELATIVES

RED-BILLED HORNBILL
Tockus erythrorhynchus
F: Bucerotidae

Tockus hornbills are small African predators, most with red or yellow bills. This species inhabits savanna and open woodland from Senegal to Namibia.

reddish bill

16½–18 in
42–45 cm

gray, white, and black plumage

white underparts

12–14 in
30–36 cm

GREEN WOOD HOOPOE
Phoeniculus purpureus
F: Phoeniculidae

This African wood hoopoe climbs trees like a woodpecker, but has a hoopoelike bill that it uses to probe rotting wood for invertebrates.

black-tipped crest, raised when landing

HOOPOE
Upupa epops
F: Upupidae

This species nests in tree-holes in Africa and Eurasia. It has a flickering, butterfly-like flight and a strong bill to dig for ground-level invertebrates.

black and white bars on wings

10–12½ in
25–32 cm

30–32 in
75–80 cm

23–26 in
58–65 cm

TRUMPETER HORNBILL
Bycanistes bucinator
F: Bucerotidae

This hornbill inhabits the forests of eastern to southern Africa. It is similar to the related silvery-cheeked hornbill, but has red facial skin.

SILVERY-CHEEKED HORNBILL
Bycanistes brevis
F: Bucerotidae

This fruit-eating pied hornbill is a forest species from eastern Africa. As with other hornbills, the male has a larger bill than the female, with a more prominent casque.

28 in
70 cm

28 in
70 cm

ORIENTAL PIED HORNBILL
Anthracoceros albirostris
F: Bucerotidae

The most widespread of the Asian pied hornbills, this bird occurs from [illegible] to Bali (Indonesia), in [illegible] land as well as forest.

MALABAR PIED HORNBILL
Anthracoceros coronatus
F: Bucerotidae

Like most other Asian hornbills, this pied species from India and Sri Lanka is omnivorous, and eats a great deal of fruit.

3¼ ft
1 m

dark plumage

blue throat pouch (only in female)

NORTHERN GROUND HORNBILL
Bucorvus abyssinicus
F: Bucorvidae

One of two predatory ground hornbills of African grasslands, this species from Senegal to Kenya tolerates drier conditions than its southern counterpart.

WOODPECKERS AND TOUCANS

Mostly tree-dwelling cavity nesters, birds of this order, the Piciformes, have a common foot structure. More than half of the species are woodpeckers.

The woodpeckers are almost worldwide in distribution. These birds cling to trunks with zygodactyl feet typical of the order (two toes pointing forward, two backward) and, propped by their stiffened tail, drum through the wood with their strong bills. They extract prey with a long barbed tongue. Other birds in the group are largely confined to the tropics. Honeyguides feed on the wax from raided bee nests. Jacamars hunt large insects, while puffbirds consume flies. Barbets have serrated bills for eating fruits; the tropical American barbets are cousins of the toucans. Honeyguides lay eggs in other birds' nests, but others in this group nest in tree-holes, burrows, or dug-out termite mounds.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PICIFORMES
FAMILIES	5
SPECIES	411

21–23½ in
53–60 cm

WHITE-THROATED TOUCAN
Ramphastos tucanus
F: Ramphastidae

Like other toucans, this species from northern South America breeds in tree cavities, often making use of abandoned woodpecker nests.

17 in
43 cm

RED-BREASTED TOUCAN
Ramphastos dicolorus
F: Ramphastidae

Among the smallest of the *Ramphastos* toucans, this species from eastern South America is the only one with extensive red underparts.

22–23½ in
55–60 cm

CUVIER'S TOUCAN
Ramphastos tucanus cuvieri
F: Ramphastidae

This Amazonian bird is often regarded as a subspecies of the white-throated toucan, from which it differs by having a darker bill.

19 in
48 cm

CHANNEL-BILLED TOUCAN
Ramphastos vitellinus
F: Ramphastidae

Ramphastos toucans are black with a white or yellow chest. In this variable South American species, the chest color depends on race.

pale orange around eye

22–26 in
55–65 cm

TOCO TOUCAN
Ramphastos toco
F: Ramphastidae

This bird from northern South America is the largest of the toucans. Unlike other forest species, it also inhabits more open woodland habitats.

massive, black-tipped orange bill

12–14 in
30–35 cm

EMERALD TOUCANET
Aulacorhynchus prasinus
F: Ramphastidae

The most widespread of a group of small green toucans, this species occurs from Mexico to Bolivia. The species consists of several races.

14 in
35 cm

♀

SPOT-BILLED TOUCANET
Selenidera maculirostris
F: Ramphastidae

This south Brazilian species is one of several dichromatic toucanets, which are the only toucans with different-colored sexes. The females are marked with brown.

blue eye skin

SAFFRON TOUCANET
Baillonius bailloni
F: Ramphastidae

Found in southeastern Brazil, this toucan has a yellow-olive plumage. It is related to the more brightly colored aracaris.

14–16 in
35–40 cm

16 in
41 cm

COLLARED ARACARI
Pteroglossus torquatus
F: Ramphastidae

With the most northerly range of the aracaris, this species occurs in humid forests from southern Mexico to northern South America.

14½ in
37 cm

ornate black bill with yellow bands

CHESTNUT-EARED ARACARI
Pteroglossus castanotis
F: Ramphastidae

Aracaris are long-tailed, gregarious toucans. Most have a red rump and prominent bands on the belly. This species is from northeastern South America.

»

7½ in
19 cm

BLACK-SPOTTED BARBET
Capito niger
F: Ramphastidae
This barbet from northern South America is rarely seen, but its froglike call is often heard.

6½ in
17 cm

RED-HEADED BARBET
Eubucco bourcierii
F: Ramphastidae
This species is found from Costa Rica to Peru. It is unusual among barbets in being largely silent.

9 in
23 cm

BLACK-BILLED BARBET
Lybius guifsobalito
F: Ramphastidae
Many African barbets occur in more open country than the forest-dwelling species of the Americas and Asia. This species occurs in East Africa.

10 in
26 cm

BEARDED BARBET
Lybius dubius
F: Ramphastidae
Barbets have sensory bristles at the base of their bill, which are much enlarged in this species from western and central Africa.

9 in
23 cm

BLUE-THROATED BARBET
Megalaima asiatica
F: Ramphastidae
Asian barbets often forage with other fruit-eaters in the forest canopy. This species occurs from the Himalayas to Thailand.

11 in
28 cm

BROWN-HEADED BARBET
Megalaima zeylanica
F: Ramphastidae
A typical Asian barbet, this species from the Himalayas, India, and Sri Lanka is a fruit-eater and especially favors figs.

green upperparts

red forehead

6½ in
17 cm

COPPERSMITH BARBET
Megalaima haemacephala
F: Ramphastidae
This is a widespread barbet found in forest edges and scrub. Its incessant "tonk-tonk" hammering call is a common sound in southern Asia.

8 in
20 cm

CRIMSON-FRONTED BARBET
Megalaima rubricapillus
F: Ramphastidae
A small Asian barbet, this species is restricted to Sri Lanka and southwestern India. It is a common species that is seen in towns.

large, yellowish bill

12½–13 in
32–33 cm

GREAT BARBET
Megalaima virens
F: Ramphastidae
The largest Asian barbet, this species is a noisy bird of highland forests from the eastern Himalayas to Thailand.

red vent

4–4¼ in
10–11 cm

RED-FRONTED TINKERBIRD
Pogoniulus pusillus
F: Ramphastidae
Restricted to riverside forests of the East African coast, this species feeds on insects and fruits, including mistletoe berries.

4–4¼ in
10–11 cm

YELLOW-RUMPED TINKERBIRD
Pogoniulus bilineatus
F: Ramphastidae
Tinkerbirds are small, black and white African barbets with repetitive calls that continue throughout the day. This species is widespread south of the Sahara.

tail narrows to point

4¼ in
11 cm

YELLOW-FRONTED TINKERBIRD
Pogoniulus chrysoconus
F: Ramphastidae
A more widespread relative of the red-fronted tinkerbird, this species occurs in dry, open woodland and savanna in sub-Saharan Africa.

9 in
22 cm

RED-FRONTED BARBET
Tricholaema diadematа
F: Ramphastidae

An East African barbet related to the spot-flanked barbet, this species occurs in drier habitats. Like other barbets, it nests in tree-holes.

9 in
22 cm

SPOT-FLANKED BARBET
Tricholaema lacrymosa
F: Ramphastidae

A barbet of damp woodlands from central to eastern Africa, the spot-flanked barbet feeds mainly on figs and berries.

6–6½ in
15–16 cm

D'ARNAUD'S BARBET
Trachyphonus darnaudii
F: Ramphastidae

Trachyphonus barbets from Africa live in open country and spend much time on the ground. D'Arnaud's barbet occurs throughout East Africa.

8 in
20 cm

TOUCAN-BARBET
Semnornis ramphastinus
F: Ramphastidae

A bird of the rain forests of Colombia and Ecuador, this species is intermediate between barbets and toucans. It is exclusively a fruit-eater.

11 in
28 cm

FIRE-TUFTED BARBET
Psilopogon pyrolophus
F: Ramphastidae

The only Asian barbet with a graduated tail, this Southeast Asian species also has tufts of facial bristles and a cicada-like call.

9 in
23 cm

RED-AND-YELLOW BARBET
Trachyphonus erythrocephalus
F: Ramphastidae

A typical African ground barbet, this bird eats insects, fruits, seeds, and even small lizards. It often burrows into termite mounds to nest.

6½ in
17 cm

4½–5 in
12–13 cm

GREEN-BACKED HONEYBIRD
Prodotiscus zambesiae
F: Indicatoridae

Honeybirds eat insects, fruits, and even beeswax. This African species lays eggs in the nests of the white-eye, a small woodland bird, and its young kill host nestlings.

NORTHERN WRYNECK
Jynx torquilla
F: Picidae

This Eurasian woodland ant-eater has a weaker bill than true woodpeckers and is named for its ability to twist its neck.

4 in
10 cm

BAR-BREASTED PICULET
Picumnus aurifrons
F: Picidae

Piculets are tiny nuthatchlike members of the woodpecker family. They use their short bills for taking insects from decayed wood. This species is from central South America.

4 in
10 cm

GOLDEN-SPANGLED PICULET
Picumnus exilis
F: Picidae

This South American piculet, like other piculets, lacks stiff, supporting tail feathers of bigger woodpeckers, so it spends less time on vertical trunks.

4 in
10 cm

OCHRACEOUS PICULET
Picumnus limae
F: Picidae

Confined to eastern Brazil, the ochraceous piculet—like other piculets—reuses woodpecker nesting holes as its bill is too small to excavate its own nest.

4 in
10 cm

OCHRE-COLLARED PICULET
Picumnus temminckii
F: Picidae

Confined to the forests of eastern Paraguay, southeastern Brazil, and northeastern Argentina, this piculet is well camouflaged by its pattern and coloration.

4 in
10 cm

SPOTTED PICULET
Picumnus pygmaeus
F: Picidae

The spotted piculet occurs only in the tropical forests of northeastern Brazil, where it is relatively common.

»

» WOODPECKERS AND TOUCANS

12 in
30 cm

GROUND WOODPECKER
Geocolaptes olivaceus
F: Picidae

Unusual in living on the ground, this South African ant-eating woodpecker inhabits barren, rocky areas and tunnels into earth banks to make a nesting chamber.

7 in
18 cm

NUBIAN WOODPECKER
Campethera nubica
F: Picidae

This relative of the European green woodpecker occurs in dry parts of northeastern Africa, where it is often seen in pairs.

7–9 in
18–22 cm

YELLOW-BELLIED SAPSUCKER
Sphyrapicus varius
F: Picidae

Sapsuckers make holes in trees to drink sap. This fork-tailed species breeds in North America and migrates to the Caribbean.

11 in
28 cm

COMMON FLAME-BACKED WOODPECKER
Dinopium javanense
F: Picidae

A tropical woodpecker, this species occurs in a variety of woodland types—including mangrove—and ranges from India eastward to Borneo and Java.

16–19½ in
40–49 cm

PILEATED WOODPECKER
Dryocopus pileatus
F: Picidae

This is the largest North American woodpecker. Unlike the Eurasian black woodpecker, American members of the genus are crested.

red cap

male has red face streak

6–6½ in
15–17 cm

HEART-SPOTTED WOODPECKER
Hemicircus canente
F: Picidae

One of two related small, crested woodpeckers from southeast Asia, this species is named for the black, heart-shaped marks on its back.

18–22½ in
45–57 cm

9 in
23 cm

GOLDEN-GREEN WOODPECKER
Piculus chrysochloros
F: Picidae

Typical of a group of green-backed woodpeckers from tropical America, this bird often follows mixed-species flocks, gleaning bark surfaces.

BLACK WOODPECKER
Dryocopus martius
F: Picidae

This large woodpecker from woodlands across northern Eurasia belongs to a small group of predominantly black species with red crowns.

12–13 in
31–33 cm

white patch on wing

7½–9 in
19–23 cm

white underparts

9½ in
24 cm

RED-BELLIED WOODPECKER
Melanerpes carolinus
F: Picidae

Like other *Melanerpes* woodpeckers, this common North American species stores food in crevices. Despite its name, the belly only has a tinge of red.

GREEN WOODPECKER
Picus viridis
F: Picidae

This European member of a group of Old World, green-backed woodpeckers is also called the yaffle after its distinct yelping call.

RED-HEADED WOODPECKER
Melanerpes erythrocephalus
F: Picidae

A distinctive woodpecker from North America, this is an aggressive species that destroys nests and eggs of other birds in its territory.

7½ in
19 cm

YELLOW-FRONTED WOODPECKER
Melanerpes flavifrons
F: Picidae

Most *Melanerpes* woodpeckers have partly barred plumage. They may also have striking colors, as does this South American species.

12 in
31 cm

ROBUST WOODPECKER
Campephilus robustus
F: Picidae

The *Campephilus* woodpeckers are black and white birds with red heads. The robust woodpecker is restricted to eastern South America.

11–17 in
28–43 cm

red patch (in male)

dark bars on wings

NORTHERN FLICKER
Colaptes auratus
F: Picidae

American flickers are named for the way their colored underwings flash in flight. This species has red- and yellow-shafted forms that hybridize.

7–10 in
18–26 cm

HAIRY WOODPECKER
Picoides villosus
F: Picidae

A North American relative of the three-toed woodpecker, this species becomes more abundant in response to the availability of its prey—the larvae of bark beetle.

8½–9 in
21–22 cm

THREE-TOED WOODPECKER
Picoides tridactylus
F: Picidae

This northern Eurasian and American bird is the most northerly woodpecker. Most woodpeckers have four toes.

red nape (in male)

9 in
22–23 cm

red patch beneath tail

GREAT SPOTTED WOODPECKER
Dendrocopos major
F: Picidae

A widespread member of a Eurasian group of pied woodpeckers, this bird is common in forests and gardens from Europe to southeast Asia.

8–9 in
20–22 cm

MIDDLE-SPOTTED WOODPECKER
Dendrocopos medius
F: Picidae

A pied woodpecker confined to Europe and southwestern Asia, this species drums less than the related great spotted woodpecker.

8 in
20 cm

CHESTNUT JACAMAR
Galbalcyrhynchus purusianus
F: Galbulidae

Jacamars specialize in catching large insects, such as butterflies, from the air. This is one of two chestnut-colored species from South America.

7 in
18 cm

iridescent green upperparts

THREE-TOED JACAMAR
Jacamaralcyon tridactyla
F: Galbulidae

The most dull-colored jacamar, this dry forest species nests in earthbanks and has two toes pointing front and one back.

11 in
28 cm

red underparts

GREAT JACAMAR
Jacamerops aureus
F: Galbulidae

This is the largest species of jacamar. It occurs from Costa Rica to Bolivia and feeds mainly on insects, supplemented by small lizards.

9 in
23 cm

RUFOUS-TAILED JACAMAR
Galbula ruficauda
F: Galbulidae

This Central and South American species is typical of its genus, characterized by iridescent green coloration above and rufous below.

5½ in
14 cm

RUSTY-BREASTED NUNLET
Nonnula rubecula
F: Bucconidae

Nunlets are small, drab-colored members of the puffbird family. This bird is a typical South American species of vine-bordered forest.

6 in
15 cm

SWALLOW-WINGED PUFFBIRD
Chelidoptera tenebrosa
F: Bucconidae

Described as martinlike when perched and batlike in flight, this bird of northern South America sallies for flying insects along rivers.

8–8½ in
20–22 cm

WHITE-EARED PUFFBIRD
Nystalus chacuru
F: Bucconidae

Like other puffbirds, this species from central South America is a big-headed, "puff-bodied" bird with a heavy bill for catching small animals.

11 in
28 cm

BLACK-FRONTED NUNBIRD
Monasa nigrifrons
F: Bucconidae

Nunbirds are black-bodied relatives of puffbirds. This noisy South American species often forages beneath monkey troops, feeding on small animals they have disturbed.

7½ in
19 cm

WHITE-WHISKERED PUFFBIRD
Malacoptila panamensis
F: Bucconidae

Malacoptila puffbirds are brown-colored birds. The white-whiskered puffbird of Central America and northwestern South America has been described as rather tame.

8–9 in
20 cm

BLACK-BREASTED PUFFBIRD
Notharchus pectoralis
F: Bucconidae

This black and white puffbird of northwestern South America may follow army ant swarms to catch insects fleeing the ants.

PASSERINES

This huge order comprises nearly 60 percent of all bird species. They are known collectively as perching birds, for their specialized feet.

Like many birds, passerines have four-toed feet with three toes pointing forward and one back. As a passerine lands, a muscle automatically tightens tendons running through the legs so that the toes lock around a perch, securing the bird even in sleep.

These birds, of the order Passeriformes, are found in almost all land habitats worldwide, from dense rain forest to arid desert and even freezing Arctic tundra. They range in size from the tiny American flycatchers, no bigger than hummingbirds, to the powerfully built Eurasian ravens.

DIVERSITY

The order includes birds adapted to a variety of feeding habits. The insect-eaters have bills like needles for probing foliage or with a wide gape for catching prey in flight. Other passerines have stubby bills for cracking open seeds, while some have long, curved bills for extracting nectar.

Passerines combine a high metabolic rate with a comparatively large brain size, giving some the resilience to tolerate cold and a few the intelligence to master the use of simple tools. They produce helpless, naked young, which are reared in nests ranging from simple cups to elaborate mud-chambers or hanging purses of woven grass. A few passerines are brood parasites, laying their eggs in the nests of other species.

SONGBIRDS

Passerines are split into two groups, largely on the basis of the structure of their vocal box. The first group, the Suboscines, includes about a fifth of all passerines. It occurs in the Old World tropics but has greatest diversity in South America; it includes broadbills, pittas, antbirds, and tyrant flycatchers. The second group, the Oscines, includes all remaining passerine families, popularly known as songbirds. Birds often communicate by voice, but the structure of their vocal box enables many passerines to deliver complex songs that are important in courtship and defending territory. Many songs are so distinctive that they can be used to identify species.

PHYLUM	CHORDATA
CLASS	AVES
ORDER	PASSERIFORMES
FAMILIES	96
SPECIES	5,962

DEBATE
OUT OF AUSTRALIA

Early DNA analysis identified two songbird groups: Corvida and Passerida. The mostly Old World Corvida includes carnivores and fruit-eaters, such as crows and birds of paradise. The global Passerida—with more than a quarter of all bird species—includes tits, sunbirds, and finches. Later techniques revealed several primitive Australian groups, such as the lyrebirds, that do not belong to either of these divisions. Together with fossil evidence, this suggests that songbirds diversified in Australasia before giving rise to Corvida and Passerida.

BROADBILLS

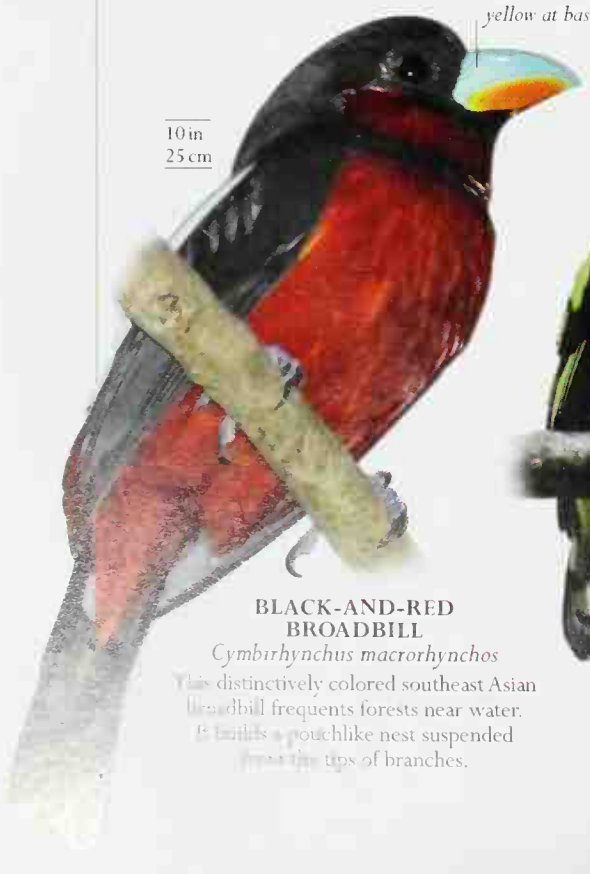
The family Eurylaimidae consists of forest-dwelling birds from tropical Africa and Asia. They mostly use their wide bills for catching insects in trees, but members of one group of Asian green broadbills are fruit-eaters.

6½–7 in
17–18 cm

GREEN BROADBILL
Calyptomena viridis
One of the three southeast Asian green broadbills, this bird is a specialist fruit-eater and builds globular hanging nests.

blue bill with yellow at base

10 in
25 cm



BLACK-AND-RED BROADBILL
Cymbirhynchus macrorhynchos
This distinctively colored southeast Asian broadbill frequents forests near water. It builds a pouchlike nest suspended from the tips of branches.

6 in
15 cm

BLACK-AND-YELLOW BROADBILL
Eurylaimus ochromalus
An Asian insect-eating broadbill, this species forages in the middle and upper levels of rain forests from Myanmar to Borneo and Sumatra.

ASITIES

The brush-tipped tongue of these Madagascan birds, the Philepittidae, suggests that they may have evolved from nectar-feeding ancestors: one genus is now fruit-eating; the other resembles the unrelated sunbirds that feed on nectar.

thin, decurved bill

3½ in
9 cm

COMMON SUNBIRD-ASITY
Neodrepanis coruscans
One of two long-billed birds from eastern Madagascar, this species evolved the nectar-feeding habit of true sunbirds, but is unrelated to them.

PITTAS

Birds of this Old World family forage for insects on the forest floor in tropical regions. The Pittidae have rounded bodies and short bills, and many species are brilliantly plumaged. Both adults incubate the eggs.

8 in
20 cm

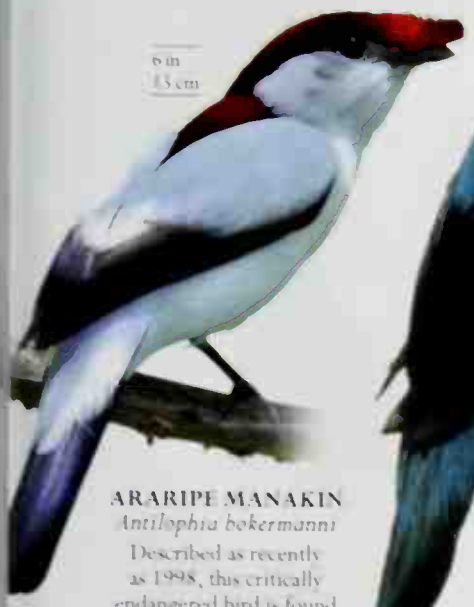
BLUE-WINGED PITTA
Pitta moluccensis
Found from southern China to Borneo and Sumatra, the blue-winged pitta inhabits dense forest when breeding, but overwinters in coastal scrub.

7½ in
19 cm

INDIAN PITTA
Pitta brachyura
Like its relatives, this pitta from the southern Himalayas, India, and Sri Lanka builds domed nests on or near the ground.

MANAKINS

These birds, the Pipridae, are related to cotingas. The brightly colored males gather in groups called leks to display to females. For many species, courtship involves elaborate dancing movements. Females build the nest and rear offspring alone.



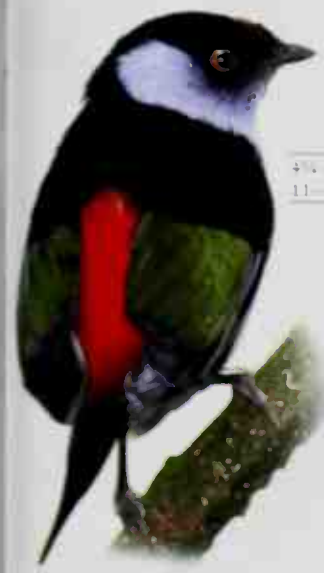
6 in
15 cm

ARARIPE MANAKIN
Antilophia bokermanni
Described as recently as 1998, this critically endangered bird is found only in the Araripe highlands of northeastern Brazil.

red cap

5½–6 in
14–15 cm

BLUE MANAKIN
Chiroxiphia caudata
One of the most colorful birds of the rain forest of southern Brazil, the blue manakin has a whining, catlike call.



4¼–5 in
11–13 cm

PIN-TAILED MANAKIN
Ilicura militaris
Males of this manakin from southeastern Brazil have elongated central tail feathers and display to females with raised rump feathers.

3½–4 in
9–10 cm

STRIPED MANAKIN
Machaeropterus regulus
This is an inconspicuous species of northern South America. Males of the species may make insectlike buzzing sounds during their display.

3½ in
9 cm

GOLDEN-HEADED MANAKIN
Pipra erythrocephala
The male of this South American species displays by jumping and whirring its wings—and sliding to one side or backward.

COTINGAS AND RELATIVES

A diverse group of tropical American passerines, the Cotingidae consists of fruit-eating or insect-eating forest birds.

Males are brightly colored and are highly vocal when courting females; some species display in trees and others on the ground.

10½–11 in
27–28 cm

BARE-THROATED BELLBIRD
Procnias nudicollis
Bellbirds are named for their metallic calls. Like other bellbirds, males of this eastern South American species have white plumage.

bright yellow throat

5 in
13 cm

FIERY-THROATED FRUIT-EATER
Pipreola chlorolepidota
Fruit-eaters are stocky green birds, males of which are usually black headed and red or yellow throated. This is a small Andean species.

glossy black body

purple-red patch

11–12 in
28–30 cm

PURPLE-THROATED FRUITCROW
Querula purpurata
Males of this distinctive Amazonian cotinga have a prominent, iridescent purplish red throat patch. It can pluck fruits while hovering in midair.

bare red skin around eye

9 in
22 cm

BLACK-TAILED TITYRA
Tityra cayana
This canopy bird belongs to a group of big-headed fruit-eaters. It nests in tree holes, often those abandoned by woodpeckers.

large crest hides the bill

brilliant red plumage

11–12½ in
28–32 cm

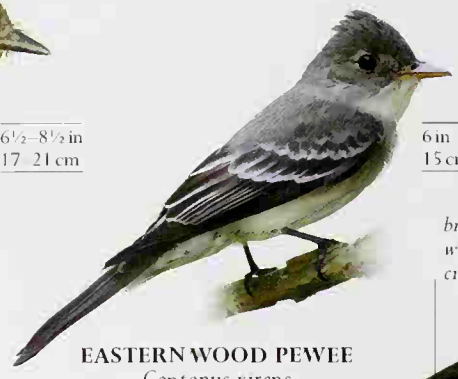
ANDEAN COCK-OF-THE-ROCK
Rupicola peruvianus
The colorful crested males of this large Andean cotinga display in groups to females. Females nest among rocks and rear young alone.

TYRANT FLYCATCHERS AND RELATIVES

Widespread throughout the Americas, these birds of the family Tyrannidae account for a third of all passerines in many South American bird communities. These birds are insectivorous and typically perch and wait for prey or glean it from foliage.

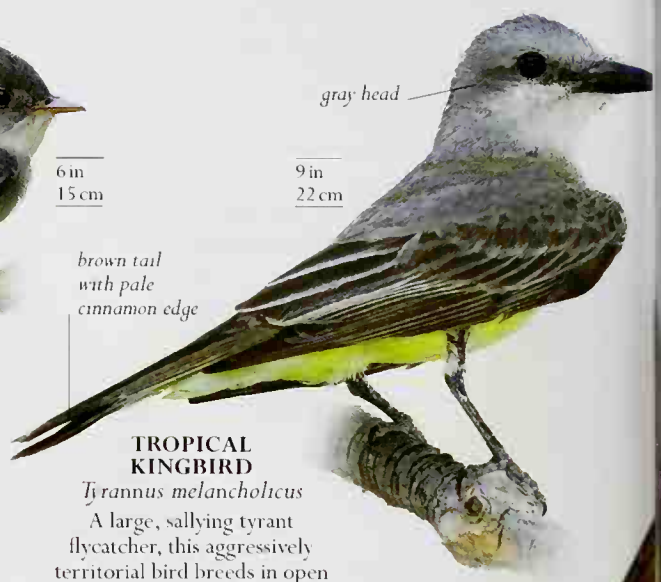
6½–8½ in
17–21 cm

GREAT CRESTED FLYCATCHER
Myiarchus crinitus
A widespread tyrant flycatcher, this large, migratory species, like its relatives, catches insects on the wing. It often hovers when foraging.



6 in
15 cm

EASTERN WOOD PEWEE
Contopus virens
This bird, with its characteristic "pewee" call, hunts by sallying—taking off from perches to catch insects in midair. It breeds in eastern North America.



9 in
22 cm

TROPICAL KINGBIRD
Tyrannus melancholicus
A large, sallying tyrant flycatcher, this aggressively territorial bird breeds in open habitats from southern North America to South America.

6 in
15 cm

VERMILION FLYCATCHER
Pyrocephalus rubinus
A species of open country, this bird forages near the ground. Males are vivid red, whereas females are mainly gray and white.

4 in
10 cm

COMMON TODY-FLYCATCHER
Todirostrum cinereum
This tiny Central and South American tyrant flycatcher is typical of a group that forages by upward striking, but prefers more open habitat than its relatives.

7½ in
19 cm

CLIFF FLYCATCHER
Hirundinea ferruginea
This flycatcher from northern and central South America is like a swallow in its aerial foraging, and perches on rocky outcrops.

6½ in
17 cm

BLACK PHOEBE
Sayornis nigricans
This tail-wagging, tyrant flycatcher forages close to the ground in tropical regions, often near water. It dives into ponds to capture minnows.

TYPICAL ANTBIRDS

From tropical American forests, these heavy-billed birds of the family Thamnophilidae hunt insects near the ground, with some following army ants to feed on insects fleeing the ants. Some are long-clawed for gripping vertical stems.

7 in
18 cm

WHITE-BEARDED ANTSHRIKE
Biatus nigropectus
This little-known, uncommon species is restricted to southeastern Brazil, where it feeds on insects in bamboo forests. It is threatened by deforestation.

ANTPITTAS AND ANT-THRUSHES

Short-tailed antpittas spend more time on the ground than the tree-dwelling ant-thrushes. Both are insectivores of South American forests and belong to the family Formicariidae.

7 in
18 cm

MOUSTACHED ANTPITTA
Grallaria alleni
A rare species found in isolated localities in Colombia and Ecuador, the moustached antpitta inhabits undergrowth in humid montane forest.

AUSTRALASIAN WRENS

The Maluridae are small, cock-tailed insect-eaters that resemble wrens of the Northern Hemisphere, but are more closely related to nectar-feeding honeyeaters. Male fairy-wrens are patterned in blue and black. Emu-wrens and grasswrens are browner birds of grassy habitats.

STRIATED GRASSWREN
Amytornis striatus
Like most other grasswrens, this central Australian species is found in spinifex grass, where family groups dart beneath bushes.

6–7 in
15–18 cm

6 in
15 cm

VARIEGATED FAIRY-WREN
Malurus lamberti
This most widespread Australian fairy-wren, like others, builds a domed nest. Young may stay near by to help raise the next brood.

SPLENDID FAIRY-WREN
Malurus splendens
Fairy-wrens form strong pair bonds, but partners may mate with other individuals. It is found mostly in southern Australia.

5½ in
14 cm

TAPACULOS AND CRESCENT-CHESTS

Strong-legged and weak-flying, these South American birds, the Rhinocryptidae, are among the most ground-adapted of South American passerines. Some have long hind claws to scratch for food in soil and leaf litter.

5½–6 in
14–15 cm

COLLARED CRESCENT-CHEST
Melanopareia torquata
Crescent-chests have longer tails than tapaculos and may belong to a separate family. This Brazilian species occurs in arid habitats.

GNATEATERS

Dumpy, short-tailed, long-legged insect-eaters of forest undergrowth, gnateaters of the family Conophagidae are secretive birds that forage near the ground using tyrantlike sallying or gleaning techniques. They are related to antbirds.

5 in
13 cm

RUFOUS GNATEATER
Conopophaga lineata
More abundant than other gnateater species, this bird from eastern South America often moves in mixed-species flocks and uses degraded habitats.

BOWERBIRDS AND CATBIRDS

The Australasian family Ptilonorhynchidae consists predominantly of fruit-eaters. Male bowerbirds—often brightly colored—build structures called bowers to attract females. They mate with many females and play no part in raising the young.

9 in
22 cm

GREAT KISKADEE
Pitangus sulphuratus
Widespread through tropical America and named for its call, this species is a typical sallying tyrant flycatcher, but also forages near the ground.

9 in
23 cm

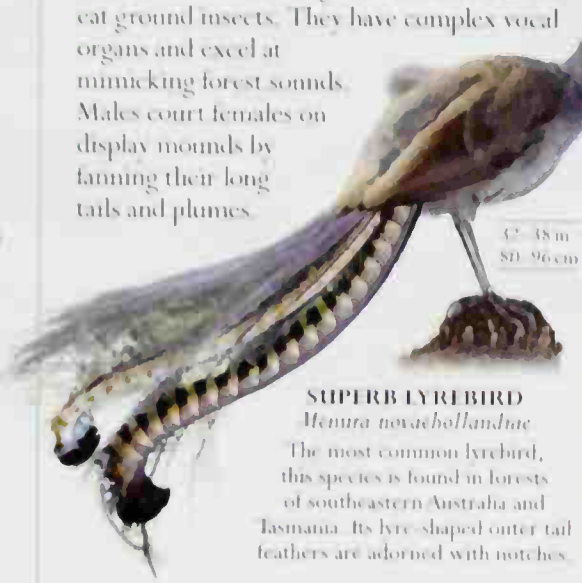
GREEN CATBIRD
Ailuroedus crassirostris
Male catbirds—named for their catlike call—attract mates by laying leaves on the ground. This species is found in New Guinea and eastern Australia.

9–10 in
23–25 cm

GOLDEN BOWERBIRD
Prionodura newtoniana
The male of this small species from northern Australia attracts a mate by building a tower of sticks up to 9¾ ft (3 m) high.

LYREBIRDS

The Menuridae are large Australian birds that eat ground insects. They have complex vocal organs and excel at mimicking forest sounds. Males court females on display mounds by fanning their long tails and plumes.



42–48 in
80–96 cm

SUPERB LYREBIRD
Menura novaehollandiae
The most common lyrebird, this species is found in forests of southeastern Australia and Tasmania. Its lyre-shaped outer tail feathers are adorned with notches.

AUSTRALASIAN TREECREEPERS

The birds of the family Climacteridae have evolved to resemble the northern treecreepers, but are unrelated and, unlike them, do not use their tail for support when climbing up trees.

6½–7 in
16–18 cm

BROWN TREECREEPER
Climacteris picumnus
This common eastern Australian species has a distinct dark-backed form in the north of the range and a brown-backed form in the south.

OVENBIRDS AND RELATIVES

These American birds, the Furnariidae, are adept at hunting hidden invertebrates and are known for the immense diversity of their nest architecture. This includes stick nests, tunnel nests, and those that resemble clay ovens.

7½–8 in
19–20 cm

WHITE-EYED FOLIAGE-GLEANER
Automolus leucophthalmus
A South American bird with distinctive white irises, like many insect-eaters, this species forages in mixed flocks to flush out prey.

7–8 in
18–20 cm

RUFOUS HORNERO
Furnarius rufus
Widespread in central and southern South America, this species, typical of the hornero group, builds an ovenlike mud nest.

HONEYEATERS

The birds of the family Meliphagidae are from Australia and the southwest Pacific islands. They feed on nectar with a long, brush-tipped tongue and are important pollinators of plants in that region. Other nectar-feeders, such as sunbirds, have evolved similar features.

4–4¼ in
10–11 cm

SCARLET HONEYEATER
Myzomela sanguinolenta
This bird is an eastern Australian member of a group of long-billed, flower-visiting honeyeaters that often carry daubs of pollen on their foreheads.

10–12 in
25–30 cm

BLUE-FACED HONEYEATER
Entomyzon cyanotis
A large, noisy honeyeater from Australia and New Guinea, this species is more insectivorous than many others, but it also feeds on fruits.

2¾–3½ in
19–21 cm

LEWIN'S HONEYEATER
Meliphaga lewinii
A member of a short-billed group of honeyeaters, this species from eastern Australia eats insects, fruits, and berries.

6½–7½ in
16–19 cm

NEW HOLLAND HONEYEATER
Phylidonyris novaehollandiae
Like other honeyeaters, this white-whiskered species from southern Australia and Tasmania also takes honeydew—the waste sugar solution produced by certain sap-sucking insects.

5–6½ in
13–16 cm

EASTERN SPINEBILL
Acanthorhynchus tenuirostris
Spinebills are an ancient group of heathland honeyeaters and the most specialized nectar-feeders of the family. This species is from eastern Australia.

13½–17½ in
29–32 cm

TUI
Prosthemadera novaeseelandiae
Although confined to New Zealand, this species is related to short-billed honeyeaters of Australia. It has an extraordinary vocal range.

WOODCREEPERS

The tropical American birds of the family Dendrocolaptidae are specialists at climbing up tree trunks. They have stiffened tails for support and strongly clawed front toes for gripping the bark.

7½ in
19 cm

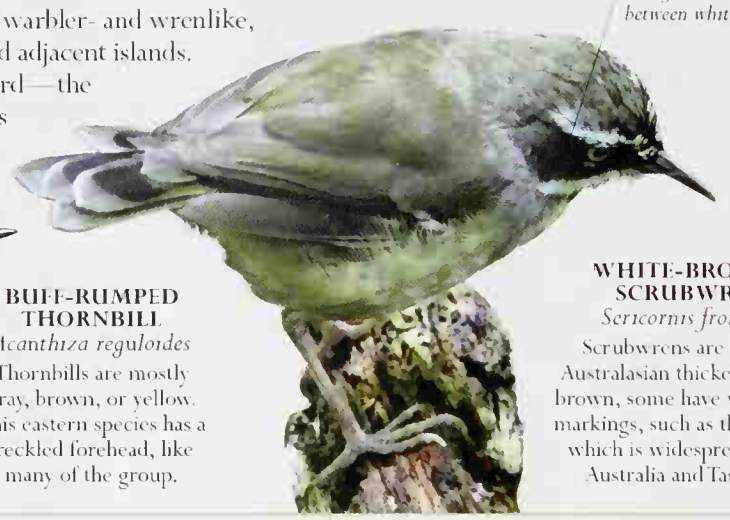
SCALLOPED WOODCREEPER
Lepidocolaptes falcinellus
This tropical buff and brown woodcreeper is found only in the forests of southeastern South America.

THORNBILLS AND RELATIVES

The Acanthizidae is a small family of warbler- and wrenlike, insect-eating birds from Australia and adjacent islands. It also includes Australia's smallest bird—the weebill. These birds have short wings and tails, and drab-colored, longish legs.

4¼ in
11 cm

BUFF-RUMPED THORNBILL
Acanthiza reguloides
Thornbills are mostly gray, brown, or yellow. This eastern species has a freckled forehead, like many of the group.



4¼–5½ in
11–14 cm

WHITE-BROWED SCRUBWREN
Sericornis frontalis
Scrubwrens are birds of Australasian thickets. Mostly brown, some have white head markings, such as this species, which is widespread across Australia and Tasmania.

PARDALOTES

Dumpy birds from Australia, the Pardalotidae have stubby bills for gleaning sap-sucking scale insects from trees. Brightly colored, they nest in deep tunnels in earth banks.

3¼–4 in
8–10 cm

SPOTTED PARDALOTE
Pardalotus punctatus
Three of the four species of pardalotes have white spots. This highly active bird is from dry forests in southern and eastern Australia.

WOODSWALLOWS

From Southeast Asia, New Guinea, and Australia, the members of the family Artamidae are unique among passerines for their powder down feathers that give them soft plumage. They catch insects in flight and are among the few small passerines that can soar.

MASKED WOODSWALLOW
Artamus personatus
This dark-faced, thick-billed woodswallow occurs in drier parts of inland Australia and is highly nomadic. Like other woodswallows, it often gathers in large flocks.

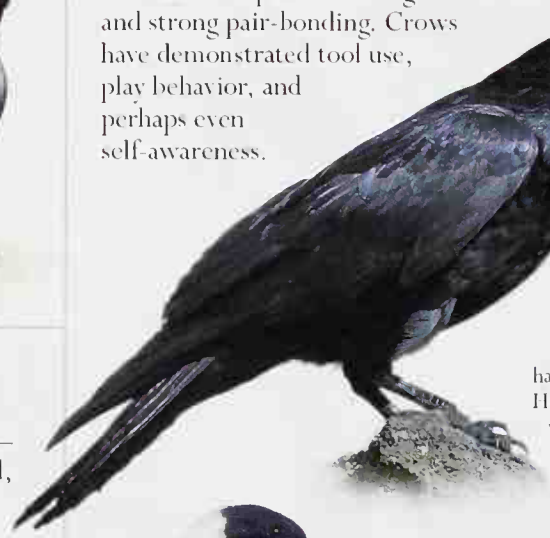
7½ in
19 cm

CROWS AND JAYS

The family Corvidae, occurring worldwide, includes some of the biggest passerines. They are intelligent, opportunistic birds that have complex social organization and strong pair-bonding. Crows have demonstrated tool use, play behavior, and perhaps even self-awareness.

13–15½ in
33–39 cm

EURASIAN JACKDAW
Corvus monedula
A small crow of western Eurasia and North Africa, this bird nests in cavities on crags, and is found on coastal cliffs and in urban areas.



22–27 in
56–69 cm

COMMON RAVEN
Corvus corax
Found in a wide range of open-country habitats across the Northern Hemisphere, this is the most widespread crow and the largest passerine.

10–12 in
25–30 cm

BLUE JAY
Cyanocitta cristata
This colorful jay of North America lives in tightly bonded family groups. It is fond of acorns and disperses them, which helps distribute oak trees.

BUTCHERBIRDS AND RELATIVES

The Australasian family Cracticidae consists of highly vocal, intelligent, omnivorous passerines. It includes predatory butcherbirds, crow-like currawongs, and mostly ground-dwelling Australian magpies. Related to woodswallows, these birds build untidy nests of twigs.

13½–17½ in
34–44 cm

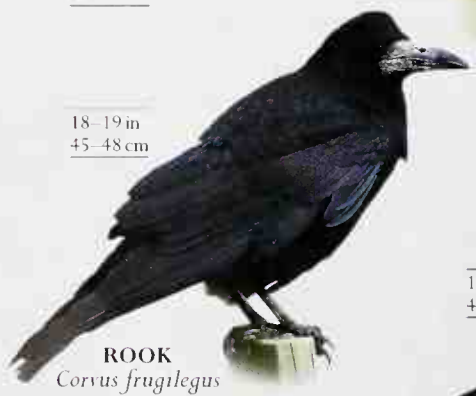
AUSTRALIAN MAGPIE
Gymnorhina tibicen
A widespread Australian species with a highly variable black and white plumage, this bird has a varied and melodious song and is a capable mimic.

18–20 in
46–50 cm

PIED CROW
Corvus albus
A relative of the raven, this heavy-billed bird of open country may be the most common member of the crow family in Africa and Madagascar.

18 in
46 cm

COMMON MAGPIE
Pica pica
This Eurasian bird is common in habitats ranging from open woodland to semidesert. It is related more closely to *Corvus* crows than Asian magpies.



18–19 in
45–48 cm

ROOK
Corvus frugilegus
Routinely flocking throughout the year in Eurasia, this hare-faced crow nests in colonies in trees in open countryside.

18½–20½ in
47–52 cm

CARRION CROW
Corvus corone
This common Eurasian, largely solitary species has a broad diet. It feeds on small animals and vegetable matter, as well as carrion.

IORAS

These rainforest birds, the Aegithinidae, are usually active in the high canopy. Their green or yellow coloration camouflages them in foliage, where they glean for insects. Males can engage in elaborate courtship displays.

6 in
15 cm

COMMON IORA
Aegithina tiphia
The smallest and most widespread iora, it is found across tropical Asia, from India to [illegible] in disturbed habitats. [illegible] cup-shaped nest.

DRONGOS

Black, long-tailed birds of Old World tropics, the Dicruridae sally for insects, bolting out suddenly to catch their prey. They are aggressive birds, and sometimes attack larger species to defend their nests.

10 in
26 cm

CRESTED DRONGO
Dicrurus forficatus
Like other drongos, this Madagascan species has a long, forked tail and red eyes. It has a distinctive tuft of feathers at the base of its bill.

SHRIKES

The family Laniidae contains predators of open country. Many species store their prey (insects and small vertebrates) by impaling them on thorns. Most occur in Africa and Eurasia; two species live in North America.

6½–7 in
17–18 cm

RED-BACKED SHRIKE
Lanius collurio
This bird breeds from Europe to Siberia and overwinters in Africa. Like other *Lanius* shrikes, it has a musical call.

BUSH-SHRIKES AND RELATIVES

The family Malaconotidae is entirely confined to Africa. They are found mostly in scrubby, open woodland, and have hooked bills for catching large insects.

8 in
20 cm

WHITE HELMET-SHRIKE
Prionops plumatus
Widespread across sub-Saharan Africa, the white helmet-shrike often gathers in small groups. This bird has a wide range of different calls.

9 in
24 cm

CRIMSON-BREASTED GONOLEK
Laniarius atrococcineus
Members of the African bush-shrike family, gonoleks have red and black plumage. This species occurs in southern Africa.

orange-red bill

36 in
67 cm

RED-BILLED BLUE MAGPIE
Urocissa erythrorhyncha
A forest bird from the Himalayas to eastern Asia, this species robs chicks from nests and plucks at carcasses.

ORIOLES

Old World passerines related to shrikes and crows, the birds of the family Oriolidae live in forest canopies and eat insects and fruits. Many species have striking yellow and black plumage. The females are usually greener than males.

9–9½ in
24 cm

EURASIAN GOLDEN ORIOLE
Oriolus oriolus
Breeding in woodlands in western and central Eurasia, this oriole migrates southwards to overwinter in Africa.

10½–11¾ in
27–29 cm

AUSTRALASIAN FIGBIRD
Sphecotheres vieilloti
Stout-billed relatives of orioles from Australasia, figbirds are gregarious fruit-eaters. This species occurs in northern and eastern Australia.

WATTLE-EYES AND RELATIVES

The Platysteiridae, wattle-eyes and their relatives, are a family of insect-eating birds from Africa. They have flat, hooked bills with bristles at the base. Like flycatchers, they snatch their prey suddenly.

5 in
13 cm

BROWN-THROATED WATTLE-EYE
Platysteira cyanea
Wattle-eyes get their name from the red skin around their eyes. This common species occurs in woodland throughout sub-Saharan Africa.

11¾ in
29 cm

GREEN JAY
Cyanocorax yncas
This bird feeds on fruits and seeds. South American populations of the green jay differ sufficiently from those of Central America to be considered as separate species.

12–14 in
31–35 cm

AZURE-WINGED MAGPIE
Cyanopica cyanus
A social species, this bird breeds in colonies. Two separate populations (in Portugal and in eastern Asia) of this gregarious woodland bird may constitute separate species.

13½ in
34 cm

EURASIAN JAY
Garrulus glandarius
More closely related to Old World crows than American jays, this colorful woodland bird habitually hoards acorns in autumn.

VANGAS AND RELATIVES

Related to helmet-shrikes of Africa, the members of the family Vangidae are predatory passerines from Madagascar. They feed on invertebrates, reptiles, and frogs, and have a range of bill shapes—chisel-, sickle-, and dagger-shaped—for different prey and feeding techniques.

8 in
20 cm

RUFOUS VANGA
Schetba rufa
Common in the forests of Madagascar, this bird resembles the shrike, but is not closely related to the shrike family.

VIREOS

Although superficially resembling American warblers but with somewhat thicker bills, the members of the family Vireonidae are more closely related to crows and to Old World orioles and shrikes. They take insects by gleaning or fly catching, and also eat some fruits.

4½ in
11 cm

BLACK-CAPPED VIREO
Vireo atricapilla
This species breeds in N. America and migrates to Mexico. Unlike other vireos, the sexes differ. The male is black-capped, while the female is gray-capped.

4½–5 in
12–13 cm

RED-EYED VIREO
Vireo olivaceus
North American populations of this very vocal vireo migrate to South America, where they join resident races of the same species.

TYPICAL TITS

These small, acrobatic, usually hole-nesting birds of the family Paridae occur in wooded habitats across North America, Eurasia, and Africa. They frequently hang upside-down to glean insects from foliage, and manipulate seeds and nuts to crack them open.

4¾–5½ in
12–14 cm

VARIED TIT
Parus varius
This species is found in forest habitats, including conifers and bamboo forests, in northeastern Asia, Japan, and Taiwan.

4¾–6 in
12–15 cm

BLACK-CAPPED CHICKADEE
Parus atricapillus
A typically inquisitive and acrobatic tit, this is a common North American bird. Like other tits, it hoards seeds for later use.

5½–6½ in
14–16 cm

TUFTED TITMOUSE
Parus bicolor
Like other tits, this eastern North American species supplements its insect diet with seeds, holding them firmly to smash them with its bill.

5½ in
14 cm

GREAT TIT
Parus major
Widespread across Eurasia, this tit occurs in habitats from forest to heathland, and has a diverse range of vocalizations.

4½–4¾ in
11–12 cm

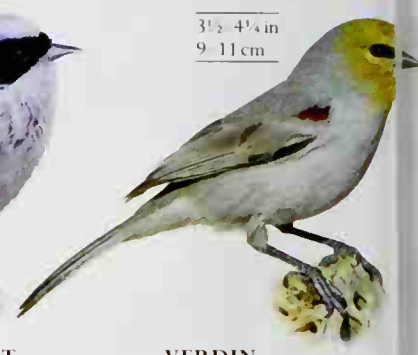
BLUE TIT
Parus caeruleus
This common bird of broadleaf woodlands in Europe, Turkey, and North Africa is a frequent visitor to bird feeders in gardens.

PENDULINE TITS

These small, needle-billed birds from the family Remizidae occur in Africa and Eurasia, with one species in America. Most use cobwebs and other soft material to build flask-shaped nests that hang from branches, often over water.

4¼ in
11 cm

PENDULINE TIT
Remiza pendulinus
The only member of the family to have a wide range across Eurasia, this species occurs on marshes with trees, where it builds its pendulous nest.



3½–4¼ in
9–11 cm

VERDIN
Auriparus flaviceps
Unlike most other penduline tits, the verdin makes a spherical nest. It is found in desert scrub of the southern USA and Mexico.

BIRDS-OF-PARADISE

Mainly found in the rain forests of New Guinea, members of the family Paradisaeidae are mostly fruit-eating birds. The males display their bright, gaudy plumes in elaborate courtship displays, and spend most of their energies on this mating ritual, leaving the females to rear the young alone.

12½ in
32 cm

LESSER BIRD-OF-PARADISE
Paradisaea minor
This species occurs across northern and western New Guinea. Males use their long, yellow flank plumes and distinctive cape for courtship displays.

AUSTRALIAN ROBINS

The Petroicidae are chunky, round-headed insect-eaters. Unrelated to the robins of Europe or America, they are found from Australasia to the islands of the southwest Pacific. Some exhibit co-operative breeding, in which young birds help their parents to raise a new brood.

5 in
13 cm

JACKY WINTER
Microeca fascinans
This common robin uses its broad bill for catching flies. It is widespread in woodland throughout Australia and New Guinea.

6 in
15 cm

EASTERN YELLOW ROBIN
Eopsaltria australis
Common in the woodlands and gardens of eastern Australia, this bird sallies from low perches for invertebrates, which it snatches from the ground.

WAXWINGS

From the family Bombycillidae, these berry-eating birds are named for the waxy, red-tipped shafts on their wings. Three species occur in the cool northern forests of North America and Eurasia.

7 in
18 cm

BOHEMIAN WAXWING
Bombycilla garrulus
This sleek bird is pinkish brown, with chestnut undertail feathers. It breeds in northern taiga forest and is attracted to berried shrubs during its migration south.

LONG-TAILED TITS

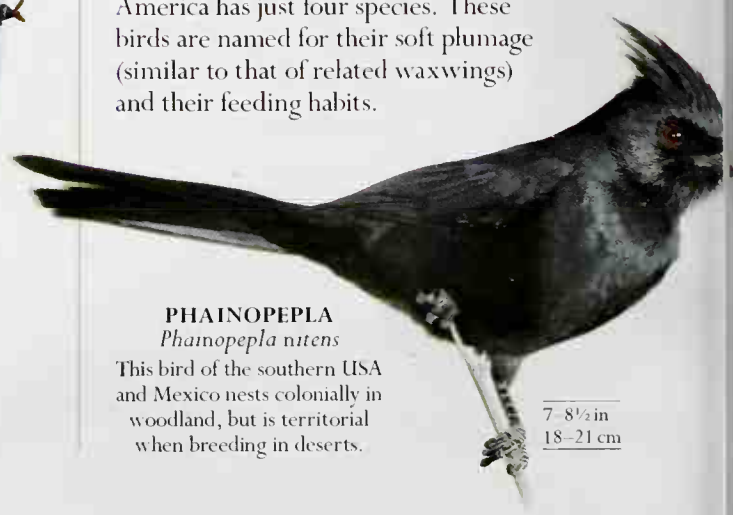
Birds of the family Aegithalidae are small, restless insect-eaters that build dome-shaped nests woven with cobwebs and lined with feathers. Most species are found in Eurasia, but one, the bushtit, occurs in North America.

5½ in
14 cm

LONG-TAILED TIT
Aegithalos caudatus
The most widespread of the family, this woodland bird inhabits a range from northern to central Eurasia, gathering in restless flocks when not breeding.

SILKY FLYCATCHERS

The family Ptilogonatidae from Central America has just four species. These birds are named for their soft plumage (similar to that of related waxwings) and their feeding habits.



7–8½ in
18–21 cm

PHAINOPEPLA
Phainopepla nitens
This bird of the southern USA and Mexico nests colonially in woodland, but is territorial when breeding in deserts.

MONARCHS AND RELATIVES

Generally long-tailed birds, members of the Monarchidae have broad bills for flycatching. Most species occur in Old World tropical forests. With the exception of the magpie-lark, they are tree-dwellers that build cup-shaped nests decorated with lichen.

black head

10–12 in
26–30 cm

rufous upperparts

AFRICAN PARADISE-FLYCATCHER
Terpsiphone viridis
This bird has variable color forms, but all males have long tail streamers. This species occurs in savanna, south of the Sahara.

long tail feather

6½–13 in
17–18 cm

MAGPIE-LARK
Grallina cyanoleuca
Unlike other members of the monarch family, this Australian bird spends much time on the ground and builds a large mud nest.

AUSTRALIAN MUDNESTERS

The family Corcoracidae contains two species of social birds that feed on the ground and build large, cup-shaped nests of grass. These are held together with mud and are made in trees on horizontal branches.

APOSTLEBIRD
Struthidea cinerea
This ground-living bird associates in flocks of 6 to 20 individuals. It occurs in woodlands of northern and eastern Australia.

11½–12½ in
29–32 cm

LARKS

Brown in color, with a melodious call, these birds from the family Alaudidae inhabit arid, open habitats. Most occur in Africa, with one species in North America. Most have long hind claws that provide the stability they need to spend so much time on the ground.

HORNED LARK
Eremophila alpestris
This lark breeds on Arctic North American and Eurasian tundra. It overwinters on coastlines farther south.

5½–6½ in
14–17 cm

7–8 in
18–20 cm

GREATER HOOPOE-LARK
Alaemon alaudipes
This long-legged lark has a curved bill and occurs in arid habitats of North Africa and the Middle East, where it habitually runs on the ground.

7–7½ in
18–19 cm

EURASIAN SKYLARK
Alauda arvensis
Common across Eurasia, from the British Isles to Japan, this open-country bird is notable for its musical aerial song.

BULBULS

Found across the warmer parts of Eurasia and Africa, most bulbuls of the family Pycnonotidae are gregarious, noisy, fruit-eating birds. The soft plumage of many species is drably colored, marked by red or yellow feathers beneath the tail.

red cheek patch

9–10 in
23–25 cm

BLACK BULBUL
Hypsipetes leucocephalus
Common in forests and gardens in India, China, and Thailand, this species exists in dark-headed and white-headed races.

8 in
20 cm

RED-WHISKERED BULBUL
Pycnonotus jocosus
A common Asian bulbul found from India to the Malay Peninsula, this is an opportunistic woodland species that is also found near villages.

SWALLOWS AND MARTINS

From the family Hirundinidae, these swiftlike birds have long wings and forked tails. Their short, flattened bills and wide gapes help them take insects on the wing. They build mud nests or use tree-holes or tunnels in banks.

8 in
20 cm

GREATER STRIPED SWALLOW
Cecropis cucullata
This African grassland swallow breeds toward the south of the continent and migrates northward to overwinter.

4½–5½ in
12–14 cm

BANK SWALLOW
Riparia riparia
Like other swallows, this species migrates south to overwinter in the tropics. It nests in colonies in riverside banks across the Northern Hemisphere.

4½–6 in
12–15 cm

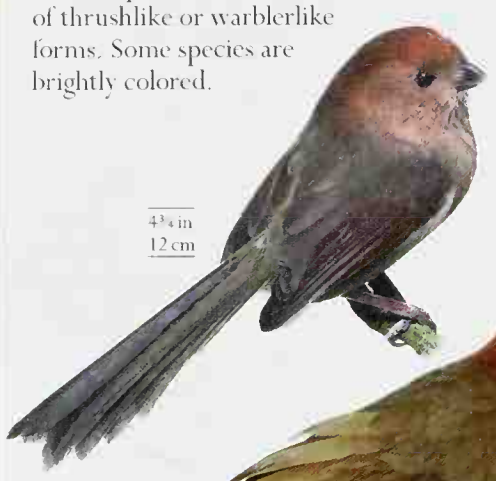
TREE SWALLOW
Tachycineta bicolor
This North American swallow of wooded swamps supplements its insect diet with berries. This enables it to breed farther north than other swallows.

6–7½ in
15–19 cm

BARN SWALLOW
Hirundo rustica
Occurring worldwide, this is the most widespread species of swallow. It was originally a cave-nester, but now uses buildings as well.

BABBLERS AND RELATIVES

Generally more gregarious, noisier, and less migratory than warblers, babblers, from the family Timaliidae, are widespread through warmer parts of the Old World, and have evolved into a variety of thrushlike or warblerlike forms. Some species are brightly colored.



4¾ in
12 cm

VINOUS-THROATED PARROTBILL
Paradoxornis webbianus

Despite its stumpy seed-cracking bill, this long-tailed Asian parrotbill may be related to the insectivorous Old World warblers. This species occurs in China.

13 in
33 cm

GREATER NECKLACED LAUGHING-THRUSH
Garrulax pectoralis

Laughing thrushes are large forest babblers with laughing calls. They often move in mixed flocks. This species inhabits the Himalayas and southeast Asia.

9 in
23 cm

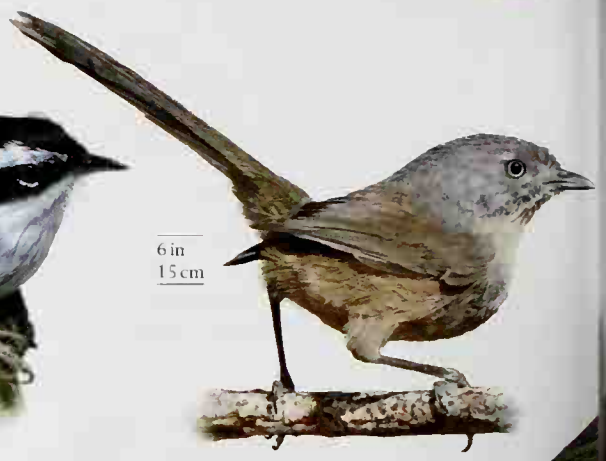
WHITE-EARED SIBIA
Heterophasia auricularis

Sibias are nectar-feeding babblers. This species is confined to Taiwan, where its distinctive call is often heard in mountain forests.

5½ in
14 cm

RED-TAILED MINLA
Minla ignotincta

This small babbler is similar to a tit. It is a noisy inhabitant of montane forest canopies in Nepal, China, and Myanmar.



6 in
15 cm

WRENTIT
Chamaea fasciata

A dull-colored bird with a cocked tail, the wrentit is the only American member of the babbler family, which may be related to parrothills.

6½ in
16–17 cm

CHESTNUT-CAPPED BABBLER
Timalia pileata

A bird of low thickets in southeastern Asia, this babbler is often found near water, along with flycatchers and other babblers.

5 in
13 cm

WHITE-NAPED YUHINA
Yuhina bakeri

Like the closely related white-eyes, crested yuhinas are adapted to take nectar. The white-naped yuhina is an eastern Himalayan species.

GNATCATCHERS

These small American insect-eaters from the family Polioptilidae are related to wrens, but are more warblerlike in appearance. Some gnatcatchers cock their tails when foraging, a behavior shared with several members of the wren family.

4¾ in
12 cm

BLUE-GRAY GNATCATCHER
Polioptila caerulea

This North American gnatcatcher may flick its white-edged tail to flush insects. Unlike related gnatcatcher species, males do not have dark head markings.

TREECREEPERS

From the family Certhiidae, these are small insect-eating birds of the Northern Hemisphere. They forage on vertical tree trunks using their tail as a prop, habitually climbing one tree and flying to the bottom of the next.

5 in
13 cm

EURASIAN TREECREEPER
Certhia familiaris

This is the most widespread *Certhia* treecreeper; it is found across Eurasia, from Britain to Japan, in broadleaf and coniferous forests.

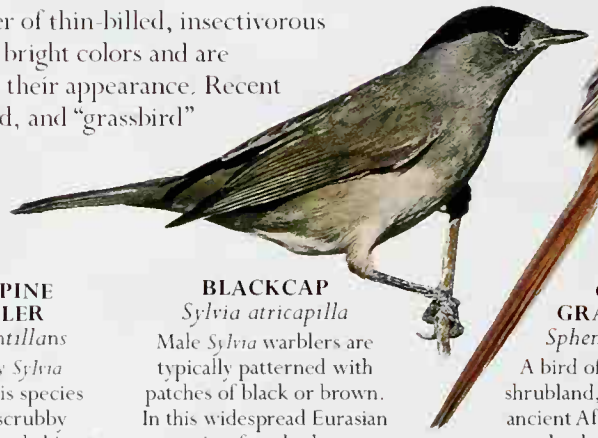
OLD WORLD WARBLERS AND RELATIVES

The family Sylviidae includes a number of thin-billed, insectivorous birds. Many Old World warblers lack bright colors and are distinguished by their call rather than their appearance. Recent DNA analysis shows that African, reed, and "grassbird" warblers belong to separate families.

4¾–5 in
12–13 cm

SUBALPINE WARBLER
Sylvia cantillans

Like many *Sylvia* warblers, this species breeds in scrubby Mediterranean habitats and winters in Africa.



5½ in
14 cm

BLACKCAP
Sylvia atricapilla

Male *Sylvia* warblers are typically patterned with patches of black or brown. In this widespread Eurasian species, females have a brown cap.

7½–9 in
19–23 cm

CAPE GRASSBIRD
Sphenoeacus afer

A bird of South African shrubland, it belongs to an ancient African group that evolved separately from other Old World warblers.

5–6 in
13–15 cm

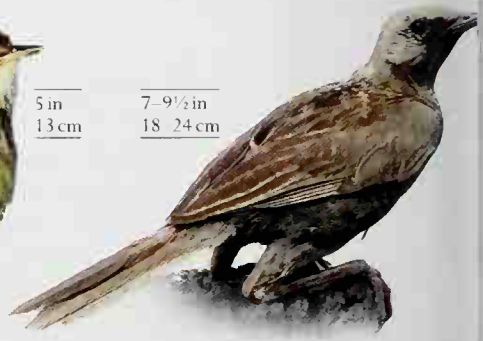
ICTERINE WARBLER
Hippolais icterina

This Eurasian woodland species has a more musical call than related reed warblers. It migrates to southern Africa in winter.

5 in
13 cm

SEDGE WARBLER
Acrocephalus schoenobaenus

This is one of many species of reed warblers (inhabitants of wetland areas) that breeds in Eurasia and winters in Africa.



7–9½ in
18–24 cm

BROWN SONGLARK
Cincloramphus cruralis

This "grassbird" warbler from Australia is a nomad of open habitats. Like larks, it sallies skyward from exposed perches.

dark red wing patch

7 in
18 cm

silver gray ear patch

SILVER-EARED MESIA
Leiothrix argentauris
A skulking, montane forest bird, this southeast Asian species belongs to a group of "song babblers," which includes mesias, sibias, and laughing thrushes.

BEARDED TIT
Panurus biarmicus
This Eurasian reed-bed specialist, possibly related to larks, eats insects in summer and hardens its stomach in winter to digest reed seeds.

6–7 in
16–17 cm

GOLDCRESTS

Among the smallest of passerines, these color-crested birds of the family Regulidae are found in cool northern forests. They have a high metabolic rate, which forces them to feed constantly when awake. They glean tiny, soft-bodied invertebrates from foliage with their needlelike bills.

3½ in
9 cm

GOLDCREST
Regulus regulus
All kinglets are adapted to coniferous forests. The Eurasian goldcrest has especially grooved feet and enlarged toe pads for clinging to needlelike leaves.

4¼ in
11 cm

RUBY-CROWNED KINGLET
Regulus calendula
The red head patch of this North American species is visible when it raises its crown feathers—a trait shared by all kinglets.

NUTHATCHES

From the family Sittidae, nuthatches are more acrobatic than the related treecreepers, being able to move down trunks as well as up. They feed on insects and seeds, sometimes hoarding them in crevices for harsher times.

WALLCREEPER
Tichodroma muraria
This central Eurasian mountain bird gleans insects from rocks with its pointed bill.

6½ in
16–17 cm

5½ in
14 cm

EURASIAN NUTHATCH
Sitta europaea
A widespread species, this forest bird can—like other nuthatches—crack open nuts by wedging them in cracks in tree bark.

black stripe across eye

4½ in
11 cm

RED-BREASTED NUTHATCH
Sitta canadensis
This North American species is similar in body pattern to the Eurasian species, but males are more vividly colored.

orange brown underparts

WHITE-EYES

Most of the Zosteropidae are characterized by a ring of white feathers around the eye. The birds of this uniform family, closely related to babblers, have brush-tipped tongues and are nectar-feeding specialists.

BROAD-RINGED WHITE-EYE
Zosterops poliogastrus
This open woodland white-eye is restricted to isolated mountain ranges in Ethiopia, Kenya, and Tanzania. Distinct races are found in different regions.

4½ in
11 cm

WRENS

With the exception of the winter wren, the family Troglodytidae is confined to the Americas. Most species are highly vocal but visually inconspicuous, short-winged birds that forage on insects in undergrowth; some even sleep on the ground.

4 in
10 cm

WINTER WREN
Troglodytes troglodytes
The only wren whose range includes Eurasia, this bird is found across the Northern Hemisphere. Over 40 local races have been described.

CACTUS WREN
Campylorhynchus brunneicapillus
The largest wren, this species occurs in deserts of California and Mexico, where it forages in flocks on the ground.

7–9 in
18–23 cm

5½ in
14 cm

BEWICK'S WREN
Thryomanes bewickii
This long-tailed wren inhabits dry, open, wooded habitats in California and Mexico. It has a variety of songs in its repertoire.

FAIRY-BLUEBIRDS

Two species of fairy-bluebirds, from the family Irenidae, are found in Southeast Asia, where they feed on fruits—especially figs—in forest canopies. Only males have a vivid blue color; females are dull green.

bright blue upper parts

ASIAN FAIRY-BLUEBIRD
Irena puella
The most widespread fairy-bluebird, found from India to Indonesia, this species often feeds with other fruit-eaters, such as hornbills and pigeons.

10 in
25 cm

MOCKINGBIRDS AND RELATIVES

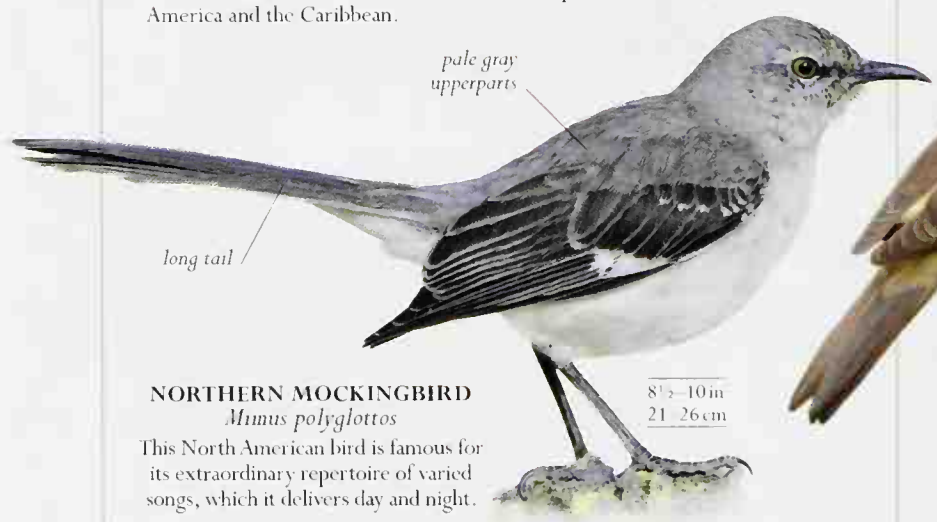
Birds of the family Mimidae occur throughout much of the Americas, and the Caribbean and Galapagos Islands. Usually gray or brown, these strong-legged birds are highly vocal; some are accomplished mimics.

8½–9½ in
21–24 cm

GRAY CATBIRD
Dumetella carolinensis
Named for its catlike mewing call, this N. American bird forages on the ground. It overwinters in Central America and the Caribbean.

10½ in
27 cm

CURVE-BILLED THRASHER
Toxostoma curvirostre
A bird of arid, scrubby habitats in the southern USA and Mexico, this species uses its long bill to probe the soil for invertebrates.



8½–10 in
21–26 cm

NORTHERN MOCKINGBIRD
Mimus polyglottos
This North American bird is famous for its extraordinary repertoire of varied songs, which it delivers day and night.

STARLINGS AND MYNAS

From the family Sturnidae, these are mostly gregarious, noisy birds, many with a glossy plumage that has a metallic sheen. This family is divided into mynas and relatives from southern Asia and the Pacific, and true starlings from Africa and Eurasia.

10½–12 in
27–31 cm

HILL MYNA
Gracula religiosa
Found in forests of tropical Asia, this species is a popular cage bird. It is notable for its melodious call and its mimicking ability.

10 in
25 cm

BALI MYNA
Leucopsar rothschildi
Found only in the rain forests of Bali, Indonesia, this striking bird is endangered because of habitat destruction and the bird trade.

20 in
50 cm

WHITE-NECKED MYNA
Streptocitta albicollis
This long-tailed, magpielike myna is restricted to rain forests in Sulawesi, Indonesia, and adjacent islands, where it usually associates in pairs.

7½–9 in
19–22 cm

YELLOW-BILLED OXPECKER
Buphagus africanus
Common in savanna across sub-Saharan Africa, this bird habitually perches on large mammals, eating parasites but also pecking at wounds.

7–7½ in
18–19 cm

EMERALD STARLING
Lamprotornis iris
This glossy West African species feeds mainly on fruits, especially figs, but also takes ants.

OLD WORLD FLYCATCHERS AND CHATS

Related to thrushes, the family Muscicapidae is divided into two groups: true flycatchers, with broad bills for snatching flying insects; and chats, which include robins, nightingales, and wheatears. Some species are brightly colored, but most of these small birds have predominantly gray or brown plumage.

7 in
18 cm

BLUE-AND-WHITE FLYCATCHER
Cyanoptila cyanomelaena
Belonging to a large group of vivid blue flycatchers from tropical Asia, this species from eastern Asia forages high in forests.

5 in
13 cm

COMMON STONECHAT
Saxicola torquatus
Typical of chats, this is a small, upright, perching insectivore with a harsh call. It is common in grassland in Eurasia and Africa.

5½ in
14 cm

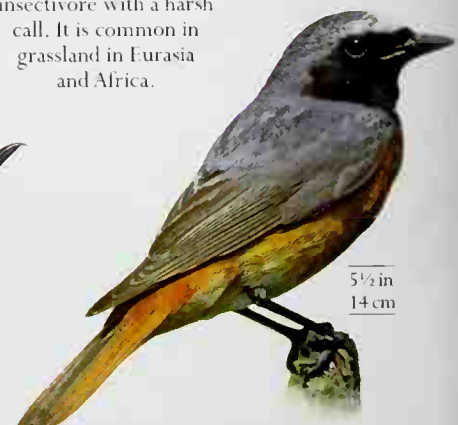
EUROPEAN ROBIN
Erithacus rubecula
Related to chats, this bird of hedgerows and woodland is found in western Eurasia and North Africa. In [illegible] a common garden visitor.

6–6½ in
15–16 cm

NORTHERN WHEATEAR
Oenanthe oenanthe
Wheatears are white-rumped chats of open country. This is the most widespread species across Eurasia. It winters in Africa.

7½–8½ in
19–21 cm

MOCKING CLIFFCHAT
Thamnolaea cinnamomeiventris
Belonging to a group of dark-colored African chats, this bird occurs in bushy, rocky habitats and can become tame near villages.



5½ in
14 cm

COMMON REDSTART
Phoenicurus phoenicurus
Named for their rufous tails, redstarts are chatlike birds found mainly in Asia. This species occurs from western to central Eurasia and migrates to East Africa.

THRUSHES AND RELATIVES

Belonging to the family Turdidae, most thrushes are woodland birds that forage on the ground for invertebrate prey, such as earthworms, snails, and insects. They are found worldwide, but the majority of species occur in the Old World. Many have melodious songs.

SPLENDID GLOSSY STARLING
Lamprotornis splendidus
Widespread in sub-Saharan Africa, this species belongs to a group of African starlings characterized by a metallic sheen on their plumage.

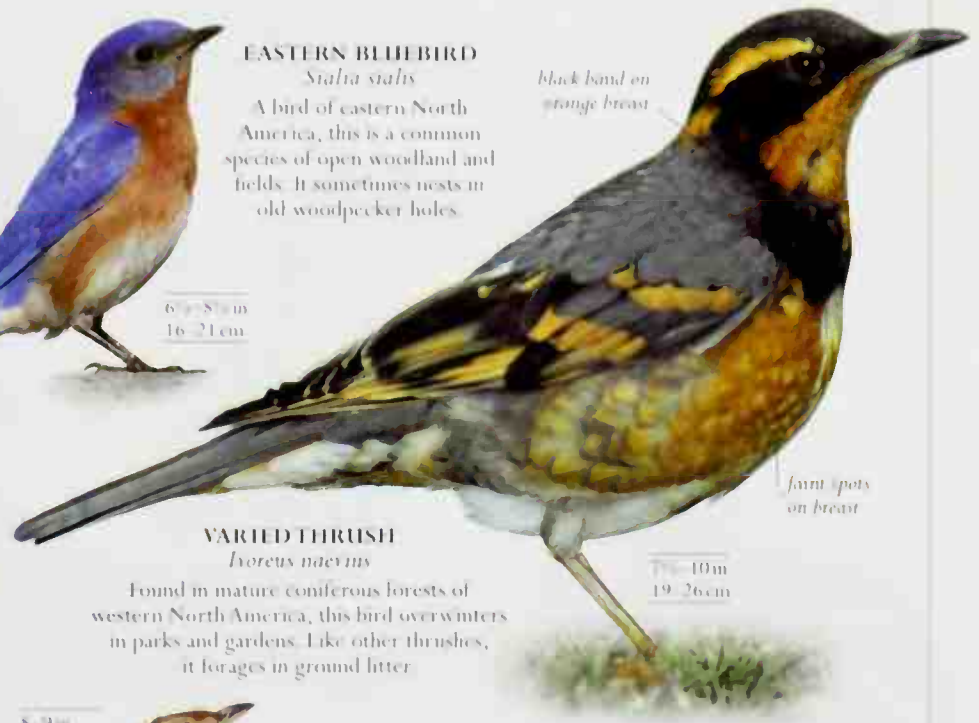
HILDEBRANDT'S STARLING
Lamprotornis hildebrandti
This East African glossy starling occurs in wooded savanna, where it preys on large ground insects, often flocking with other starling species.

EUROPEAN STARLING
Sturnus vulgaris
Native to Eurasia but introduced to North America, this common starling roosts communally, in groups that gather after mass aerial maneuvers.

WHITE-BROWED SHORTWING
Brachypteryx montana
Perhaps more closely related to flycatchers than thrushes, shortwings are running birds found in Asian forests. This species occurs from the Himalayas to Java, Indonesia.

ORANGE-HEADED THRUSH
Zoothera citrina
One of many tropical Old World *Zoothera* thrushes, this species is found in forests from the Himalayas to Bali, Indonesia.

EASTERN BLUEBIRD
Sialia sialis
A bird of eastern North America, this is a common species of open woodland and fields. It sometimes nests in old woodpecker holes.



VARIED THRUSH
Ixoreus naevius
Found in mature coniferous forests of western North America, this bird overwinters in parks and gardens. Like other thrushes, it forages in ground litter.

BLUETHROAT
Luscinia svecica
One of the 10 races of bluethroats breeds in the far north, from Sweden to Alaska, and migrates to Africa, the Middle East, and southeast Asia.

WHITE-TAILED ROBIN
Myiomela leucura
A bird of riverine forests from the Himalayas to Indochina, it usually keeps close to the ground unless disturbed.

COMMON NIGHTINGALE
Luscinia megarhynchos
This brown bird of western to central Eurasian thickets is known for its loud, rich song, which it sings night or day.

PIED FLYCATCHER
Ficedula hypoleuca
This large genus of mainly Asian flycatchers is closely related to chats. This woodland species ranges from Europe to Siberia.

SONG THRUSH
Turdus philomelos
Found from Europe to Siberia, this woodland and garden bird habitually uses a hard surface as an "anvil" to smash open snail shells.

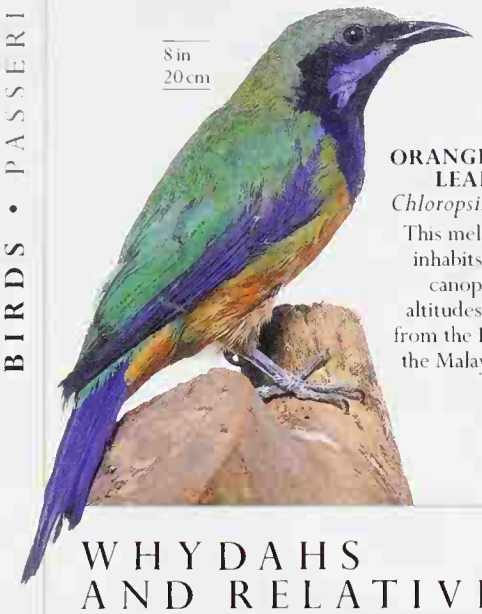
AMERICAN ROBIN
Turdus migratorius
Unrelated to the European robin, this North American thrush sometimes gathers in massive winter roosts thousands of birds.

EURASIAN BLACKBIRD
Turdus merula
A common long-tailed thrush of woodland habitats ranging from Europe and North Africa to India, the highly territorial blackbird often visits gardens.

FIELDFARE
Turdus pilaris
This bird breeds in northern Eurasia and winters farther south, where it flocks together in fields.

LEAFBIRDS

The fruit-eating birds of the family Chloropseidae occur in forests in southeastern Asia. They use their brush-tipped tongues to take nectar, with which they supplement their diet. Male leafbirds are characteristically green, with blue or black throats.



8 in
20 cm

ORANGE-BELLIED LEAFBIRD
Chloropsis hardwickei
This melodious bird inhabits the forest canopy at high altitudes, in a range from the Himalayas to the Malay Peninsula.

WHYDAHS AND RELATIVES

African whydah birds and related indigobirds of the family Viduidae are cuckoolike brood parasites of waxbills. The mouthparts and begging behavior of the chicks usually resemble those of the host chicks, thus fooling the host parents.

4¾–15 in
12–38 cm

EASTERN PARADISE WHYDAH
Vidua paradisaea
Typical of whydahs, breeding males of this East African species have extraordinarily long tail feathers, which they use in display flights.

WAXBILLS AND RELATIVES

Consisting of small, highly gregarious, often brightly colored seed-eaters, the family Estrildidae occurs in tropical Africa, Asia, and Australia. Many birds live in grassland or open woodland and build domelike nests. Both parents share parental duties.

4 in
10 cm

ZEBRA FINCH
Taeniopygia guttata
Native to the drier parts of Australia, the zebra finch is a popular cagebird around the world.

6½ in
16 cm

JAVA SPARROW
Lonchura oryzivora
This vulnerable species from Java and Bali frequents farmland and feeds on cereal crops. It has been hunted as a rice pest and for the pet trade.

5½ in
14 cm

PURPLE GRENADIER
Uraeginthus ianthinogaster
An East African bird of dry woodland, the purple grenadier belongs to a genus of predominantly blue waxbills.

4 in
10 cm

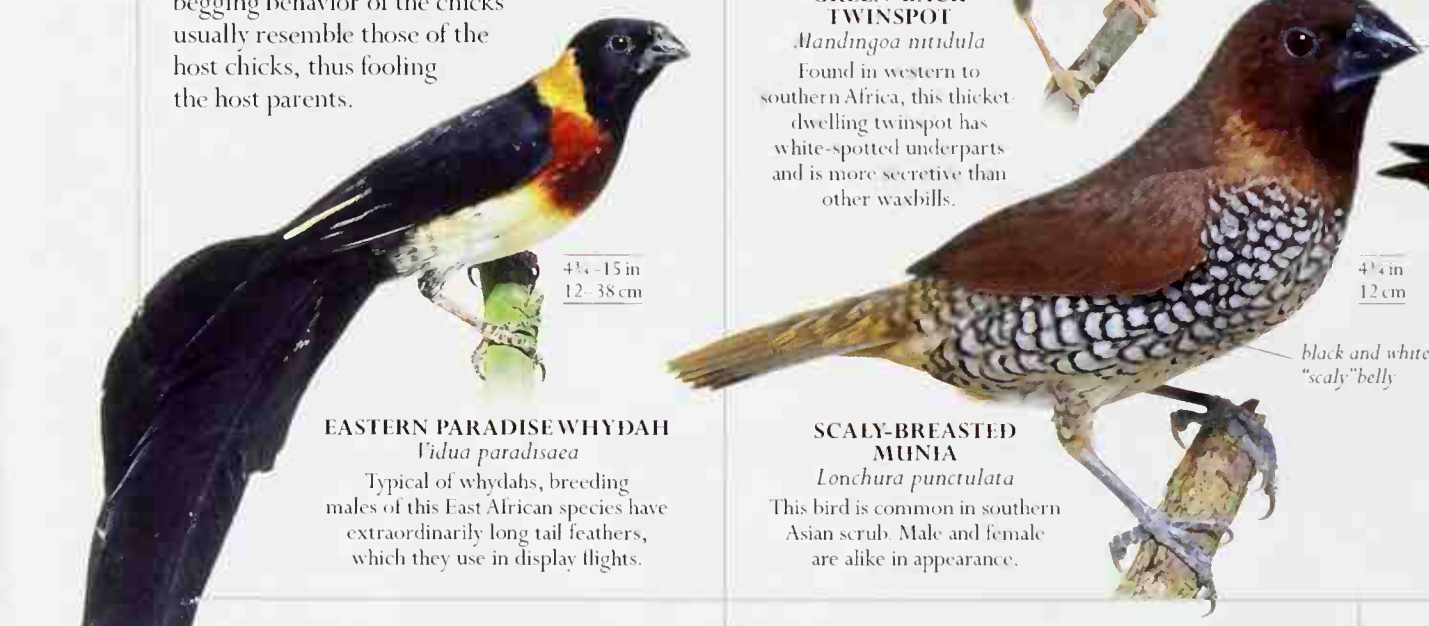
COMMON WAXBILL
Estrilda astrild
Abundant throughout Africa, this tiny waxbill, like related species, is a restless, flocking bird of open land, feeding on grass seeds.

4¾ in
12 cm

GREEN-WINGED PYTILIA
Pytilia melba
Male *Pytilia* waxbills have red splashes on their wings. This African species is host to the paradise whydah (*Vidua paradisaea*), a brood parasite.

4 in
10 cm

GREEN-BACK TWINSPOT
Mandingoa nitidula
Found in western to southern Africa, this thicket-dwelling twinspot has white-spotted underparts and is more secretive than other waxbills.



4¾ in
12 cm

SCALY-BREASTED MUNIA
Lonchura punctulata
This bird is common in southern Asian scrub. Male and female are alike in appearance.

4¾ in
12 cm

RED-THROATED PARROTFINCH
Erythrura psittacea
Parrotfinches are waxbills with mostly green bodies from southeastern Asia to the Pacific Ocean. This species occurs in grasslands of the island of New Caledonia.

FLOWERPECKERS

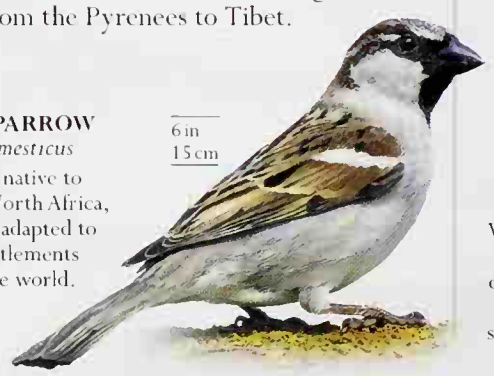
These dumpy birds of the family Dicaeidae are related to the sunbirds from tropical Asia and Australasia. Largely fruit-eating, like sunbirds, they take nectar from flowers. The flowerpeckers differ in having shorter bills.

4–4¼ in
10–11 cm

MISTLETOEBIRD
Dicaeum hirundinaceum
This Australian flowerpecker has a small gut to process mistletoe berries rapidly, and plays an important role in dispersing seeds of this parasitic plant.

OLD WORLD SPARROWS

These stubby-billed, seed-eating birds, family Passeridae, are found across Africa and Eurasia. In addition to the true sparrows, the group includes snowfinches, mountain-dwelling birds that occur from the Pyrenees to Tibet.



6 in
15 cm

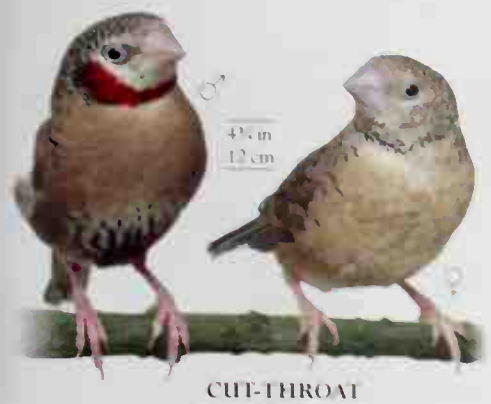
HOUSE SPARROW
Passer domesticus
Originally native to Eurasia and North Africa, the bird has adapted to human settlements around the world.

DIPPERS

Belonging to the family Cinclidae, dippers are the only passerines that can dive and swim underwater. They have adaptations for their aquatic lifestyle, such as well-oiled, waterproof feathers and oxygen-storing blood.

7 in
18 cm

WHITE-THROATED DIPPER
Cinclus cinclus
Widespread through temperate Eurasia, the white-throated dipper breeds near fast-flowing streams but may move to slower-flowing rivers in winter.



CUT-THROAT
Amadina fasciata
Named for the male's red neck patch, this is a common bird of dry African woodlands, and is often found near human habitations.

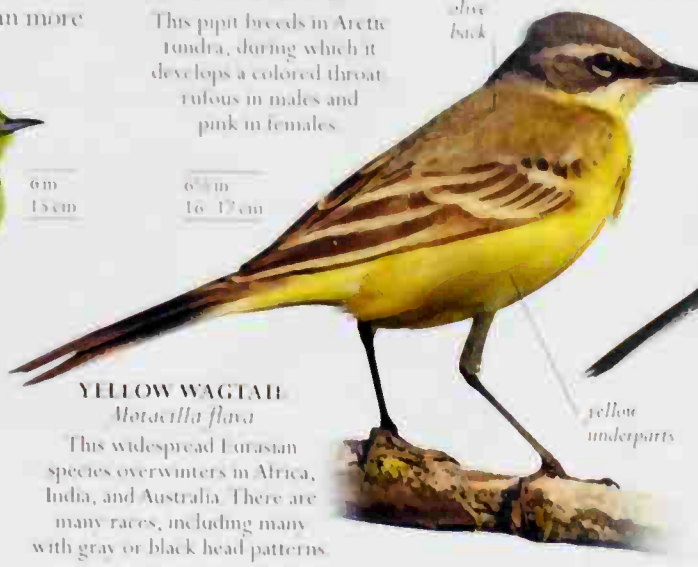
PIPITS AND WAGTAILS

Present on every continent, the birds of the family Motacillidae inhabit open country, where they feed on insects. Most wagtails have longer tails and are more brightly colored than more somber pipits, and some are associated with water.

RED-THROATED PIPIT
Anthus cervinus
This pipit breeds in Arctic tundra, during which it develops a colored throat rufous in males and pink in females.

BUFF-BELLIED PIPIT
Anthus rubescens
A typical ground-running pipit, this species breeds in Arctic tundra and winters in fields and on coasts further south.

GOLDEN PIPIT
Tmetothylacus tenellus
A bird of open bush and grassland, the golden pipit is confined to East Africa, from Sudan to Tanzania.



YELLOW WAGTAIL
Motacilla flava
This widespread Eurasian species overwinters in Africa, India, and Australia. There are many races, including many with gray or black head patterns.

WHITE WAGTAIL
Motacilla alba
A typical wagtail, this species is widespread throughout Eurasia often on farmland or in towns.

SUNBIRDS

The small, fast-moving, nectar-feeding Old World tropical birds of the family Nectarinidae are similar to American hummingbirds, with their long, decurved bills and long tongues. Males are usually brightly colored with a metallic sheen. These birds are fiercely territorial.

GOULDIAN FINCH
Erythrura gouldiae
A brilliantly colored relative of parrotfinches, this endangered bird of northern Australia is nomadic. Males can have red or black faces.

STREAKY-BREASTED SPIDERHUNTER
Arachnothera affinis
Spiderhunters are drab, long-billed members of the sunbird family. Like other sunbirds, this Southeast Asian species eats invertebrates as well as nectar.

SCARLET-CHESTED SUNBIRD
Chalcomitra senegalensis
Common throughout much of sub-Saharan Africa, this large sunbird occupies a variety of wooded habitats.

PURPLE SUNBIRD
Cinnyris asiaticus
Like other sunbirds, this species from southern Asia feeds its young mostly on insects. The male loses its brilliant plumage after breeding.

WEAVERS

Gregarious seed-eaters, the Ploceidae build elaborate nests. Males usually take sole responsibility for this duty; females use the nest as the basis for choosing mates. Most species are African, with a few found in southern Asia.

CHESTNUT WEAVER
Ploceus rubiginosus
The genus *Ploceus* includes the largest number of species of weavers. This one occurs in East Africa.

RED-BILLED QUELEA
Quelea quelea
Widely considered the world's most abundant bird, this African species gathers in flocks that can cause serious damage to crops.

RED-COLLARED WIDOWBIRD
Euplectes ardens
Breeding males of widowbirds are black and some fan enlarged tails during display flights. This species is widespread in sub-Saharan Africa.

YELLOW-CROWNED BISHOP
Euplectes afer
This African bird is related to widowbirds. Breeding males are vibrantly patterned; females and nonbreeding males are red or black.

ACCENTORS

Mostly ground-dwelling passerines, the Prunellidae have narrow bills and are found in Eurasia. Most species are adapted to high altitudes, but they move to lower altitudes in winter to supplement their insectivorous diet with seeds.

DUNNOCK
Prunella modularis
Unlike other accentors, this is a lowland bird, and it does not usually gather in flocks. It is widespread in temperate Eurasia.

FINCHES AND RELATIVES

Finches of the family Fringillidae have diversified in Eurasia, Africa, and the tropical regions of the Americas. From thin-billed nectar-feeders to heavy-billed, seed-cracking grosbeaks and hawfinches, these birds have evolved to cope with a wide range of foods.

4¾ in
12 cm

EURASIAN GOLDFINCH
Carduelis carduelis

Goldfinches have thinly pointed bills for taking seeds from the seedheads of tall plants, such as thistles. This species is widespread in Eurasia.

4¾–5 in
12–13 cm

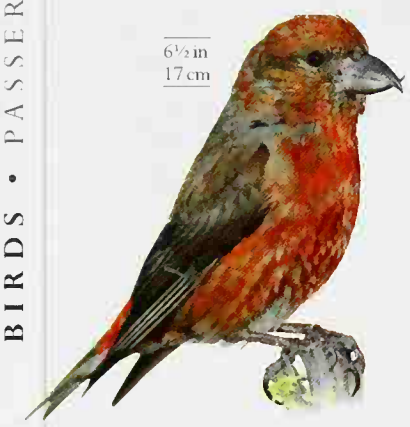
AMERICAN GOLDFINCH
Carduelis tristis

Bright yellow goldfinches and siskins have diversified in the Americas, especially in South America. This migratory species is from North America.

6 in
15 cm

CHAFFINCH
Fringilla coelebs

The most common finch in Europe, the chaffinch is also found throughout northern Asia. It often forages with other finch species in winter.



6½ in
17 cm

RED CROSSBILL
Loxia curvirostra

Crossbills use their uniquely crossed mandibles for extracting seeds from cones. This species is widespread in coniferous forests across the Northern Hemisphere.

4¾ in
12 cm

YELLOW-FRONTED CANARY
Serinus mozambicus

This bird belongs to a group of mostly yellow-colored African serins and canaries. It is common south of the Sahara.

6–6½ in
15–17 cm

GRAY-CROWNED ROSY FINCH
Leucosticte tephrocotis

A member of a group of mountain finches related to bullfinches, this North American species is an inhabitant of high, rocky landscapes.

large, white wing patch

AMERICAN BLACKBIRDS AND RELATIVES

These American species of the family Icteridae superficially resemble the common blackbird, to which they are not related. As a group, the birds are more closely related to the finches. They have strong bills, which have a powerful gaping action for prying apart tough food.

8½–10 in
21–26 cm

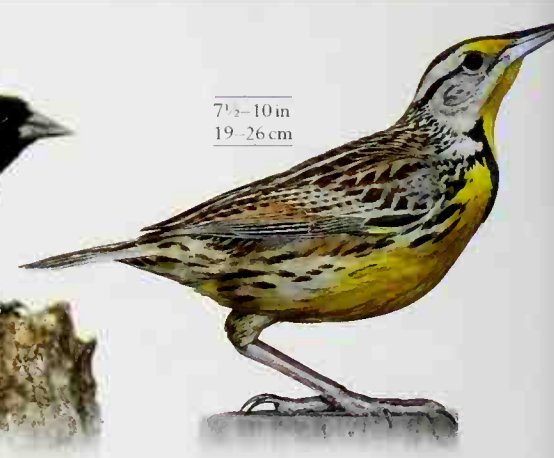
YELLOW-HEADED BLACKBIRD
Xanthocephalus xanthocephalus

This marshland bird of western North America breeds in colonies and sites its nests over water, perhaps to deter predators.

6½–9½ in
17–24 cm

RED-WINGED BLACKBIRD
Agelaius phoeniceus

A North American bird of marshy habitats, this colonial nester often breeds in the company of the larger, more dominant, yellow-headed blackbird.



7½–10 in
19–26 cm

EASTERN MEADOWLARK
Sturnella magna

A species from eastern North America, this open-country bird builds a nest on the ground, covering it with a grass roof.

11–13½ in
28–34 cm

COMMON GRACKLE
Quiscalus quiscula

An opportunistic North American species, this bird raids refuse dumps and corn crops. Its internally keeled bill can saw open acorns.

7½–9 in
19–22 cm

BROWN-HEADED COWBIRD
Molothrus ater

This North American bird produces many eggs, laying them in the nests of other species. Its young are raised by many different host species.

black head

7–8 in
18–20 cm

orange underparts

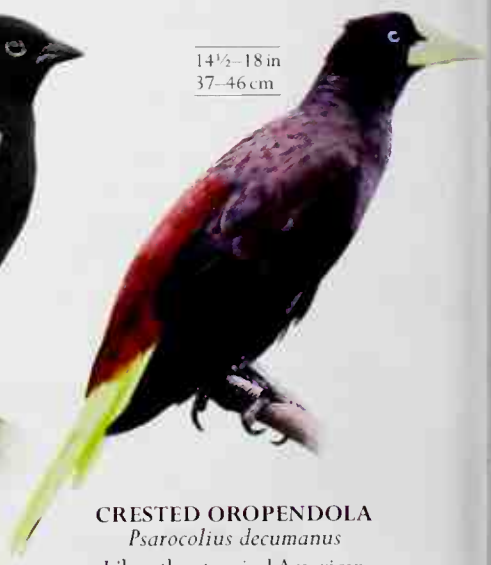
BALTIMORE ORIOLE
Icterus galbula

Feeding on insects and caterpillars in spring and summer, this species changes its diet in winter to include nectar and berries.

6–8 in
15–20 cm

BOBOLINK
Dolichonyx oryzivorus

This ground-nesting North American bird gets its name from its bubbling flight song. It migrates to central South America.



14½–18 in
37–46 cm

CRESTED OROPENDOLA
Psarocolius decumanus

Like other tropical American oropendolas, this colonial species weaves long nests that hang from tips of branches in open forest.

yellow forehead

8 in
20 cm

EVENING GROSBEAK
Hesperiphona vespertina
Grosbeaks of the finch family have heavy seed-crushing bills, a feature they share with the unrelated grosbeaks of the cardinal-grosbeak family. This is a North American species.

5¼ in
14 cm

HOUSE FINCH
Carpodacus mexicanus
The North American house finch is a species of rosefinch, which are are especially diverse in temperate Asia. The males are red or pale colored.

black crown and chin

pale gray back

9 in
22 cm

JAPANESE GROSBEAK
Eophona personata
A strikingly patterned bird, the Japanese grosbeak of cold northern forests breeds in Siberia and northern Japan and winters in southern China.

8 in
20 cm

PINE GROSBEAK
Pinicola enucleator
The pine grosbeak occurs in coniferous forests in the Northern Hemisphere. The bill of this grosbeak resembles that of the closely related bullfinches.

5½ in
14 cm

IIWI
Vestiaria coccinea
This long-billed nectar-eater is found only in Hawaii. It is a bird of montane forests, the largest populations occurring at higher elevations.

6–6¼ in
15–16 cm

EURASIAN BULLFINCH
Pyrrhula pyrrhula
Bullfinches have short, thick bills and thick-set heads. This is the most widespread of the bullfinches and is found in woodlands across temperate Eurasia.

AMERICAN WARBLERS

Unrelated to warblers of the Old World, these finch-related insect-eaters of the family Parulidae are found throughout North and South America. The tropical species are sedentary, but temperate ones are migratory. The males molt their bright colors in winter.

yellow body

4¾–5 in
12–13 cm

5½ in
14 cm

4¼–5½ in
11–14 cm

COMMON YELLOWTHROAT
Geothlypis trichas
A bird of wet habitats, this is a migratory species like other North American warblers. It winters in California and Mexico.

dull brown feet and legs

YELLOW WARBLER
Dendroica petechia
Widespread from North America to the Caribbean, there is a large number of local races of yellow warblers.

BAY-BREASTED WARBLER
Dendroica castanea
This bird breeds in spruce forests in eastern North America. Its numbers fluctuate according to the abundance of its prey, the spruce budworm.

4¼–5 in
11–13 cm

AMERICAN REDSTART
Setophaga ruticilla
An active forager, this North American warbler habitually flashes its orange and black wings and tail to flush out insects. It also catches prey in the air.

7 in
18 cm

YELLOW-BREASTED CHAT
Icteria virens
This North American bird is large for a warbler. It sings at night as well as during the day, and mimics the calls of other birds.

black and white streaks overall

4¼–5½ in
11–14 cm

BLACK-AND-WHITE WARBLER
Mniotilta varia
This North American warbler moves up and down tree trunks like a nuthatch, and has long hind claws for clinging to bark.

6 in
15 cm

NORTHERN WATERTHRUSH
Seiurus noveboracensis
A large, tail-bobbing ground warbler of North America, this bird forages in leaf litter of wet woodlands and nests in thickets near water.

5 in
13 cm

5 in
13 cm

PROTHONOTARY WARBLER
Protonotaria citrea
Unusual for American warblers, this species of densely wooded swamps nests in tree cavities—sometimes using old woodpecker holes.

HOODED WARBLER
Wilsonia citrina
Like the American redstart, this bird from broadleaf woodland of the eastern USA feeds on insects by catching flies while in flight.

4¾ in
12 cm

GOLDEN-WINGED WARBLER
Vermivora chrysoptera
A warbler of eastern North America, this bird breeds in scrubby, open habitats and farmland, and benefits from deforestation.

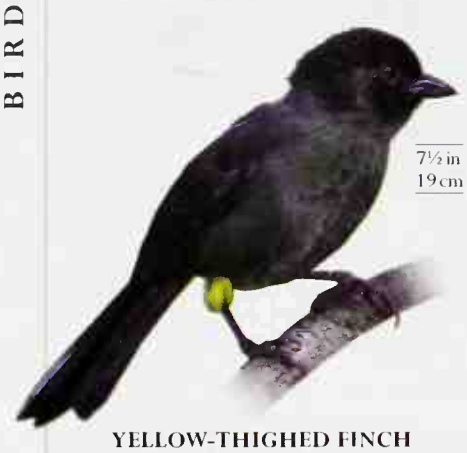
BUNTINGS AND RELATIVES

True buntings are conical-billed, mostly ground-feeding seedeaters of the Old World. New World members of this family, the Emberizidae, are collectively known as American sparrows, but they are unrelated to the sparrows of Africa and Eurasia.

SPOTTED TOWHEE
Pipilo maculatus
Towhees are long-tailed American sparrows. The spotted towhee is a rufous-sided bird found in thicket habitats across North America.

BLACK-HEADED BUNTING
Emberiza melanocephala
An inhabitant of scrub and olive groves, the black-headed bunting breeds in the Middle East and winters in India.

LARK-BUNTING
Calamospiza melanocorys
A bird of the North American prairies, the lark-bunting is a ground-nesting member of the American sparrow group.



YELLOW-THIGHED FINCH
Pselliophorus tibialis
A noisy, tropical member of the American sparrow group, this species is found only in the montane rain forests of Costa Rica and Panama.

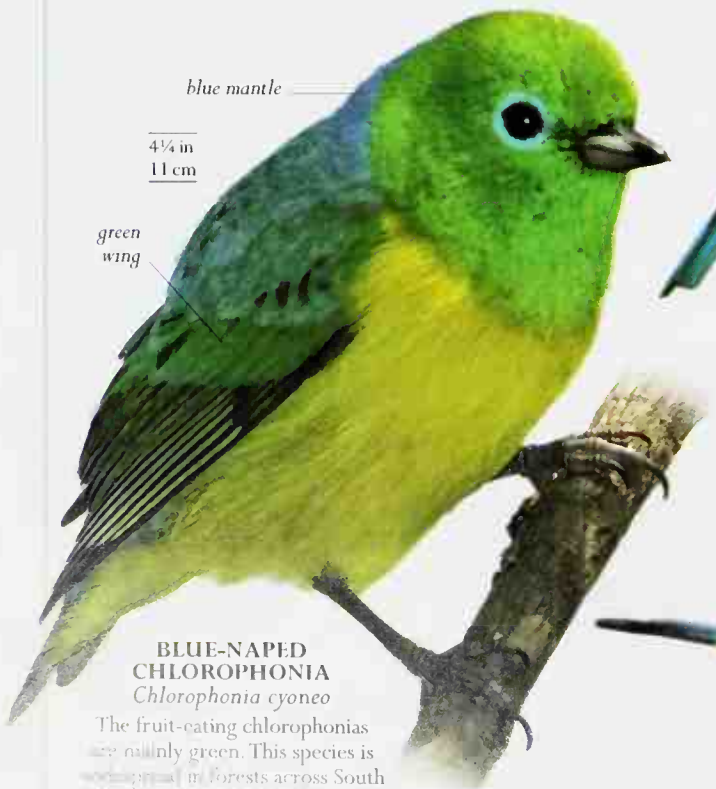
LARGE GROUND FINCH
Geospiza magnirostris
This seed-eater is a native of the Galapagos Islands. The species feeds less from the ground than other ground finches.

BLACK-MASKED FINCH
Coryphaspiza melanotis
A ground-feeding finch of grassland habitats in central South America, this species has uncertain affinities, but may belong to the tanager family.

RED-CRESTED CARDINAL
Paroaria coronata
Birds of the *Paroaria* genus are found in South America. This is a common species in open woodland.

TANAGERS AND RELATIVES

An American family, the Thraupidae consist of gaudily colored tanagers, found in the forests of tropical South America. These finch-related birds have evolved to exploit a range of food sources, including fruits, insects, seeds, and nectar.



BLUE-NAPED CHLOROPHONIA
Chlorophonia cyanea
The fruit-eating chlorophonias are mainly green. This species is widespread in forests across South America. Unlike other tanagers, it makes a domed nest.

GREEN HONEYCREEPER
Chlorophanes spiza
This stocky species lives in forest canopy and uses its stout, decurved bill to eat fruits. It is often seen in mixed flocks of tanagers.

SCARLET TANAGER
Piranga olivacea
In most species of *Piranga* tanager, the males turn red during breeding. This migratory species is from North America.

WESTERN TANAGER
Piranga ludoviciana
This bird breeds in western North America and overwinters in Central America. It is the only *Piranga* tanager with a predominantly yellow breeding male.

BLUE-WINGED MOUNTAIN TANAGER
Anisognathus somptuosus
Most mountain tanagers of northern South America are colored blue and yellow, including this inhabitant of montane rain forests.

GOLDEN-COLLARED TANAGER
Iridosornis jelskii
A member of a group of Andean forest tanagers with a yellow head streak, this species occurs in Peru and Bolivia.

SONG SPARROW
Melospiza melodia

A common North American bird from Alaska to Mexico, there are a large number of races. It is named for its melodious song.

VARIABLE SEEDEATER
Sporophila corvina

Belonging to a group of tropical American, stubby-billed seedeaters that may be allied to tanagers, this bird has a variable plumage pattern.

LAPLAND LONGSPUR
Calcarius lapponicus

Relatives of buntings, longspurs have been named for their long hind claw. This species has a circumpolar distribution during the breeding season.

DARK-EYED JUNCO
Junco hyemalis

Juncos are gray-brown, ground-flocking North American sparrows. This species, locally called the snowbird, is a common winter visitor of garden bird feeders.

WHITE-CROWNED SPARROW
Zonotrichia leucophrys

This North American bird is usually found in low vegetation or on the ground. It has distinctive black and white head markings.

CHIPPING SPARROW
Spizella passerina

A rufous-capped bird common in open woodland across North America, the chipping sparrow has a distinctive "chipping" trill.

FOX SPARROW
Passerella iliaca

Widespread throughout North America, this large sparrow has a red-streaked back and chest. It usually forages in low vegetation.

RED-LEGGED HONEYCREEPER
Cyanerpes cyaneus

Tropical American honeycreepers feed on nectar. The most widespread species, this bird has a decurved bill. Like females, males develop a dull green "eclipse" plumage after breeding.

PURPLE-THROATED EUPHONIA
Euphonia chlorotica

Euphonias are small birds that mainly eat fruits, especially mistletoe berries. This species is from northern South America.

BLUE-NECKED TANAGER
Tangara cyanicollis

This open forest bird from northern South America belongs to a group of tanager species with particularly colorful, iridescent plumage.

CARDINALS AND RELATIVES

These mostly chunky-billed birds are seedeaters like buntings, and many have bright colors like tanagers. Related to both, the Cardinalidae belong to a large group of American passerines that are derived from finches.

ROSE-BREASTED GROSBEAK
Pheucticus ludovicianus

This migratory American cardinal grosbeak has a typically heavy bill for feeding on large seeds and on insects, such as beetles.

NORTHERN CARDINAL
Cardinalis cardinalis

The males of this resident of the eastern USA and Mexico are red, due to chemicals called carotenoids that are acquired from their diet.

PAINTED BUNTING
Passerina ciris

This species breeds in the southern USA and winters in Central America and the Caribbean. Only males have the striking tricolored pattern.

INDIGO BUNTING
Passerina cyanea

The most wide ranging of the blue buntings, this species migrates between Canada and South America. The males lose their blue plumage in winter.

MAMMALS

The mammals are very successful animals. They are able to occupy almost every terrestrial habitat, and some visit the deep oceans between breaths of air. However, this has not always been the case; at 200 million years old, mammals are a relatively recent group.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDERS	29
FAMILIES	153
SPECIES	About 5,500

A single jawbone articulated directly to the skull gives mammals, such as this Tasmanian devil, a powerful bite.

Baleen is made of a protein called keratin, and baleen whales use it to strain sea water, trapping food in their mouths.

By sucking milk from their mother, young warthogs obtain all the nourishment they need during the first weeks of life.

DEBATE

EQUALLY WELL ADAPTED

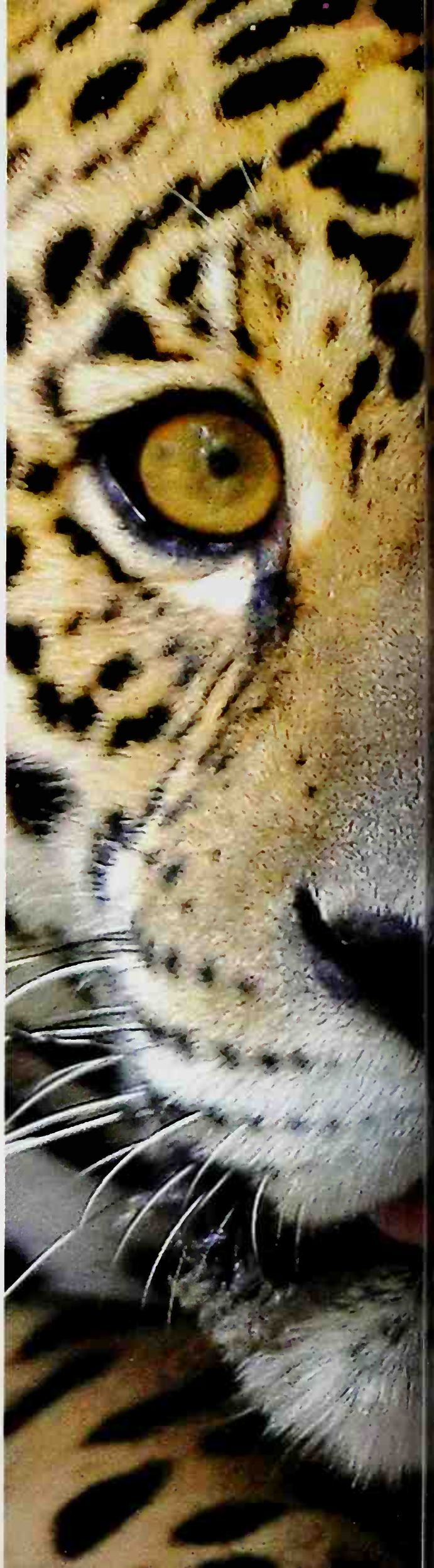
Marsupial features, including slightly reduced body temperature, are sometimes described as primitive. This implies that marsupials, whose young are born in an embryonic state and develop in a pouch, are less advanced than placental mammals, which bear [illegible] young. In fact, both [illegible] the same time.

Mammals owe their success to a unique combination of adaptations that allowed them to replace reptiles as the dominant form of animal life on Earth. Like reptiles, mammals breathe air, but unlike their scaly ancestors, they are warm-blooded, so they are able to burn fuel (food) in order to maintain a constant, warm body temperature. This creates conditions in which the internal chemical processes that sustain life can happen most efficiently, without relying directly on heat from the sun. Uniquely, mammals have hair, which reduces heat loss and allows an animal to be active in cold climates and at night. Because fur can be molted and regrown, it is seasonally adjustable too.

VARIATIONS ON A THEME

The basic mammal skeleton is strong, with upright limbs supporting the body from below. This arrangement allows land-dwelling mammals to walk, run, and leap, but the basic structure is highly adaptable, and has been modified for swimming, as in seals and cetaceans; for flying, as in bats; and for climbing or swinging through the trees, as in some primates. The skulls of mammals have powerful jaws, with a single lower jawbone articulating directly with the skull, and a diverse range of teeth adapted to a huge variety of food types. Certain other bones, which in reptiles contribute to the lower jaw, are put to a new use by mammals—they have became the three tiny bones of the inner ear, allowing for greatly enhanced hearing. The mammalian skull also serves to protect the brain, which is larger in mammals than in other groups, hinting at increased processing power. With a big brain comes intelligence, and an unrivaled ability to learn, to remember, and to engage in complex behavior.

These abilities take time to fine-tune, and young mammals do so during the extended period of parental care that begins while they are being fed on milk produced by their mother's mammary glands. These unique organs evolved from sebaceous glands, which originally provided secretions to condition the skin and perhaps to prevent eggs from drying out, and it is for them that the entire group is named.



FUR AS CAMOUFLAGE >
The markings on the fur of this jaguar break up its outline, making it more difficult for the animals it hunts to see it.

MAMMAL GROUPS

There are three groups of mammals—the egg-laying monotremes, the pouched mammals (or marsupials), and the placental mammals. The latter group is the most diverse, and is here divided into further groups.

EGG-LAYING MAMMALS

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POUCHED MAMMALS

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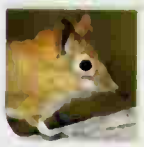

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GOLDEN MOLES AND TENRECS

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DUGONG AND MANATEES

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HYRAXES

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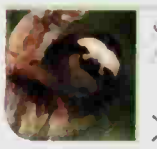
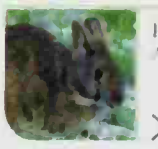


SLOTHS AND ANTEATERS

» 520



RABBITS, HARES, AND PIKAS

» 521

RODENTS

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TREE SHREWS

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FLYING LEMURS

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PRIMATES

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BATS

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HEDGEHOGS AND MOONRATS

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MOLES, SHREWS, AND SOLENODONS

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PANGOLINS

» 561

CARNIVORES

» 562

ODD-TOED UNGULATES

» 588

EVEN-TOED UNGULATES

» 594

WHALES, PORPOISES, AND DOLPHINS

» 612

EGG-LAYING MAMMALS

There are just five species in this group of mammals, which are known as monotremes. They all have specialized snouts and lay eggs.

The monotremes, which are the duck-billed platypus and the long-nosed and short-nosed echidnas, form the order Monotremata. They are found in various habitats in New Guinea, Australia, and Tasmania.

Platypuses and echidnas lay soft-shelled eggs that hatch after around ten days' incubation. The young feed on milk secreted from the female's mammary glands; monotremes have no teats. Infant echidnas live in their mother's pouch until their spines appear and then, like young platypuses, stay in a burrow for several months.

Monotremes have specialized snouts for finding and eating prey. The platypus, which is partly aquatic, has a flattened, duck like bill covered with sensory receptors that allow the animal to locate invertebrates under water, even in murky conditions. The long, cylindrical snout and long tongue of the land-dwelling echidna are ideal for probing the nests of ants and termites, and for catching worms. Neither the platypus nor the echidnas have teeth; instead they have grinding surfaces or horny spines on their tongues.

WHAT'S IN A NAME

The word "monotreme" means "single hole" and makes reference to the cloaca, a single posterior body opening into which the digestive, urinary, and reproductive tracts empty.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	MONOTREMATA
FAMILIES	2
SPECIES	5

The large, webbed feet of the duck-billed platypus are used for propulsion. The hind feet act as rudders.

DUCK-BILLED PLATYPUS

The sole member of the family Ornithorhynchidae, the duck-billed platypus is well adapted to a semi-aquatic lifestyle. It has a streamlined body, waterproof fur, webbed feet, and a flattened tail. Males have a venomous horny spur on each hind foot.

16–23½ in
40–60 cm

PLATYPUS
Ornithorhynchus anatinus
Found in rivers and streams in eastern Australia and Tasmania, this rare species uses its soft bill, which is covered in electroreceptors, to hunt for invertebrates.

ECHIDNAS

The family Tachyglossidae is made up of the long- and short-beaked echidnas. Their rounded bodies are covered with fur and spines, and the long snouts are ideal for seeking out insects, ants, and worms.

12–18 in
30–45 cm

SHORT-BEAKED ECHIDNA
Tachyglossus aculeatus
Widespread in Australia, Tasmania, and New Guinea, the short-beaked echidna lays a single egg into a pouch on the abdomen.

23½–39 in
60–100 cm

EASTERN LONG-BEAKED ECHIDNA
Zaglossus bartoni
The largest of the monotremes, this species lives in the forested highlands of eastern New Guinea.

POUCHED MAMMALS

These mammals bear live young that are born in a very immature state, and typically complete their growth in the mother's abdominal pouch.

Marsupials inhabit a vast array of habitats from desert and dry scrub to tropical rain forest. Most of them are either terrestrial or arboreal, but several glide, one is aquatic, and there are two marsupial moles that live underground. The diets of marsupials are equally wide-ranging: among the different species are carnivores, insectivores, herbivores, and omnivores. There are even marsupials that feed on nectar and pollen. Marsupials also differ markedly in size, from the tiny planigales, which are among the smallest mammals in the world, weighing less than about ⅓ oz (4.5 g), to the red kangaroo, males of which can weigh over 200 lb (90 kg).

EARLY DEVELOPMENT

Young marsupials are born blind and furless. They make their way through the mother's fur and latch onto a nipple and suckle. In around half of marsupial species, the nipples are located in a protective pouch. Some marsupials have only one offspring at a time, but others may have up to a dozen or more. The phase during which young are in the pouch is equivalent to the gestation period of placental mammals.

Kangaroos and some other marsupials are able to stop the development of an embryo before it implants in the uterus if they already have an infant occupying the pouch. The pregnancy continues when the pouch is vacated.

THE SEVEN ORDERS

Pouched mammals, known as marsupials, are now divided into seven major groups. These are: the American opossums, order Didelphimorphia; the shrew opossums, order Paucituberculata; monito del monte, the sole member of the order Microbiotheria; the Australasian carnivorous marsupials, order Dasyuromorphia; bandicoots, order Peramelemorphia; the marsupial moles, order Notoryctemorphia; and the Australasian marsupials of Diprotodontia, the largest order of pouched mammals, which includes the koala, wombats, possums, wallabies, and kangaroos.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	7
FAMILIES	18
SPECIES	289

DEBATE

NOT SO PRIMITIVE?

Pouched mammals were once considered primitive because their young are born at an early stage without prolonged nourishment by a placenta inside the mother. Scientists now know that this reproductive strategy is an adaptation to their environment and that pouched mammals are just as advanced as placental mammals. Kangaroos can support two dependent juveniles of different ages, and a fertile egg that can develop almost immediately should anything happen to the other two. This strategy allows pouched mammals to recover quickly when harsh environmental conditions abate.

SHREW OPOSSUMS

Fewer incisor teeth distinguish the members of the family Caenolestidae from other American marsupials. All six species occur in the Andes in western South America.

3½–5½ in
9–14 cm

SHREW OPOSSUM
Caenolestes obscurus
Living at high altitudes in Colombia, Ecuador, and Venezuela, this shrew opossum uses its large lower incisors to kill prey.

MONITO DEL MONTE

The sole member of the family Microbiotheriidae, the monito del monte, or colocolo, is well adapted to its cold habitat, by having dense fur on its body and ears and by hibernating during winter.

3½–5 in
8–13 cm

MONITO DEL MONTE
Dromiciops gliroides
Inhabiting cool bamboo forest and temperate rainforest in Chile and Argentina, this species has dense fur to limit heat loss.

MARSUPIAL MOLES

Two species of Australian marsupial moles form the family Notoryctidae. Their short limbs, large claws, and horned nose shield help them burrow. They lack external ears and have nonfunctional eyes.

5–5½ in
13–14.5 cm

SOUTHERN MARSUPIAL MOLE
Notoryctes typhlops
This marsupial mole is specialized for burrowing in the sandy desert and spinifex grassland of central Australia.

OPOSSUMS

The New World opossums of the family Didelphidae have pointed muzzles with sensitive whiskers, and naked ears. Many species have a grasping, prehensile tail that helps when climbing. Some opossums lack pouches.

13–20 in
33–50 cm

VIRGINIA OPOSSUM
Didelphis virginiana
The largest American marsupial, this species lives in grasslands and temperate and tropical forests in the USA, Mexico, and Central America.

7–11.5 cm
18–29 cm

BROWN-EARED WOOLLY OPOSSUM
Caluromys lanatus
Also known as the western woolly opossum, this arboreal, solitary opossum inhabits moist forests in western and central South America.

6½–11 in
16–28 cm

BARE-TAILED WOOLLY OPOSSUM
Caluromys philander
This woolly opossum's long, prehensile tail helps it move through the canopy of moist rain forests across eastern and central South America.

»

» OPOSSUMS

4¼–5¾ in
11–14.5 cm

dark fur around large eyes

prehensile tail

COMMON MOUSE OPOSSUM
Marmosa murina

Widespread in forests, pampas, and plantations in South America, this agile, nocturnal climber has a long, prehensile tail.

4¾–9 in
12–22 cm

WOOLLY MOUSE OPOSSUM
Micoureus sp.

Living in Central and South America, this pouchless marsupial with thick, woolly fur is arboreal, nocturnal, and omnivorous.

10–16 in
26–40 cm

WATER OPOSSUM
Chironectes minimus

The only aquatic marsupial, this opossum of Central and South America is also unique in that both sexes have a pouch that can close underwater.

4½–5½ in
11–14 cm

ELEGANT FAT-TAILED MOUSE OPOSSUM
Thylamys elegans

Like several other opossums, this marsupial from Chile stores fat in its tail as winter approaches.

5¼–5¾ in
13–14.5 cm

PATAGONIAN OPOSSUM
Lestodelphys halli

Living in shrub, savanna, and grassland in Argentina, the Patagonian opossum has the most southerly distribution of any opossum species.

dependent young

white spot above eye

4–6 in
10–15 cm

10–14 in
25–35 cm

GRAY FOUR-EYED OPOSSUM
Philander opossum

This opossum has white spots on its forehead, making it look as if it has four eyes. It lives in Mexico, and Central and South America.

GRAY SHORT-TAILED OPPOSUM
Monodelphis domestica

Found in Argentina, Brazil, Bolivia, and Paraguay, this short-tailed opossum sometimes inhabits human dwellings, as well as forest, scrub, and grassland.

NUMBAT

The numbat is the only member of the family Myrmecobiidae. It has a distinctive striped coat, strong claws for digging, and a very long tongue for extracting termites from their nests.

8–11 in
20–28 cm

NUMBAT
Myrmecobius fasciatus

Found only in eucalyptus forest and woodland in Western Australia, this diurnal marsupial is a specialized termite eater.

BILBIES

The family Thylacomyidae has only one species, since the lesser bilby has been declared extinct. Living in arid habitats, this nocturnal marsupial does not need to drink water because it absorbs moisture from its food.

12–22 in
30–55 cm

GREATER BILBY
Macrotis lagotis

A burrowing species of the desert of central Australia, this marsupial has silky fur, a tricolored tail, and long, rabbitlike ears.

QUOLLS, DUNNARTS, AND RELATIVES

The family Dasyuridae is made up of more than 70 large and small carnivorous marsupials with strong jaws and sharp canine teeth. These animals also have sharp claws, except on their big toe.

3¾–4¾ in
9.5–10.5 cm

FAT-TAILED FALSE ANTECHINUS
Pseudantechinus macdonnellensis
This nocturnal insect-eater stores fat in the base of its tapered tail. It inhabits arid rocky habitats of central and Western Australia.

5½–10 in
14–25 cm

BROWN ANTECHINUS
Antechinus stuartii
Endemic to forests in eastern Australia, the brown antechinus is unusual because all males die within a month of mating.

6½–10 in
17–25 cm

TASMANIAN DEVIL
Sarcophilus harrisii
The largest carnivorous marsupial in the world, this nocturnal hunter lives in a variety of habitats across Tasmania.

20½–32 in
52–80 cm

THREE-STRIPED DASYURE
Myoictis melas
This marsupial's coloration helps it to remain camouflaged on the rainforest floor in the islands of Indonesia and New Guinea.

10–16 in
26–40 cm

WESTERN QUOLL
Dasyurus geoffroii
Also called the chuditch, this nocturnal hunter from southwest Australia is mainly ground-dwelling, although it can climb trees.

3½–4¾ in
9–12 cm

RED-TAILED PHASCOGALE
Phascogale calura
Possessing a brush of black hair on its red-based tail, this carnivorous marsupial inhabits woodland in southwest Australia.

4¾–8 in
12–20 cm

MULGARA
Dasycercus cristicauda
This carnivore from west and central Australia inhabits arid and semi-arid habitats, such as desert, heath, and grassland. It stores fat in its tail.

2¾–4 in
7–10 cm

KULTARR
Antechinomys laniger
This fast, agile marsupial uses its large hind feet to bound across woodland, grassland, and semi-desert habitats in southern and central Australia.

2¼–2½ in
5.5–6.5 cm

NARROW-NOSED PLANIGALE
Planigale tenuirostris
This flat-headed, nocturnal, rodentlike marsupial lives in low shrub and dry grassland in southeast Australia.

2–3 in
5–7.5 cm

INLAND NINGAUI
Ningaui ridei
A shrewlike marsupial with a pointed snout, this nocturnal predator hunts insects in arid spinifex grassland in central Australia.

2¼–3½ in
6–9 cm

FAT-TAILED DUNNART
Sminthopsis crassicaudata
Living in open grassland in southern Australia, this small, nocturnal marsupial stores fat reserves in its tail.

BANDICOOTS

These omnivorous marsupials are found across Australia and New Guinea. Characterized by fused toes on their hind feet and more than two well-developed lower incisor teeth, the Peramelidae also have short, coarse, or spiny hair.

8–20 in
20–50 cm

SPINY BANDICOOT
Echymipera kalubu
This forest-dwelling, nocturnal insect-eater of New Guinea has a conical snout, spiny coat, and a hairless tail.

11–14 in
28–36 cm

SOUTHERN BROWN BANDICOOT
Isoodon obesulus
This short-nosed bandicoot lives in the shrubby heathland in southern Australia and several islands, including Kangaroo Island and Tasmania.

12–16½ in
31–42 cm

LONG-NOSED BANDICOOT
Perameles nasuta
Found in rain forest and woodland in eastern coastal Australia, this nocturnal bandicoot digs for its insect food.

10½–14 in
27–35 cm

EASTERN BARRED BANDICOOT
Perameles gunnii
Named for the creamy bands of fur on its flanks, this bandicoot lives in grassland and grassy woodland in Australia and Tasmania.

KOALA

The sole member of the family Phascolarctidae, the koala is adept at climbing because of its powerful forearms, opposable fingers and toes, and sharp, curved claws. It sleeps for 20 hours each day because its diet of eucalyptus leaves is low in nutrients.

large, white, rounded ears

dense fur

26–32 in
65–82 cm

KOALA
Phascolarctos cinereus
Feeding almost exclusively on eucalyptus leaves, the koala lives in forest and woodland in eastern Australia. It is solitary and nocturnal.

long, curved claws

PYGMY POSSUMS

These small, nocturnal marsupials with prehensile tails are omnivorous, feeding on insects, fruits, nectar, and pollen. Four species of the family Burramyidae are endemic to Australia; the fifth lives in Australia and New Guinea.

4¼ in
10.5 cm

LONG-TAILED PYGMY POSSUM
Cercartetus caudatus
This arboreal marsupial is found in temperate rain forest in New Guinea and northeast Queensland.

4–5 in
10–13 cm

dull, grayish brown upperparts

MOUNTAIN PYGMY POSSUM
Burramys parvus
A ground-dweller of rocky, upland habitats in Australia, the mountain pygmy possum hibernates under snow for several months during winter.

WOMBATS

Stocky marsupials with short tails and limbs, wombats have large forepaws and long claws for burrowing. The family Vombatidae feed on coarse grass, which they grind using strong jaws, and digest with an elongated gut.

COMMON WOMBAT
Vombatus ursinus
Found in forest, heathland, and coastal scrub in southeast Australia, this species is capable of digging tunnels up to 655 ft (200 m) long.

28–47 in
70–120 cm

30–37 in
77–95 cm

silky fur mottled brown and gray

SOUTHERN HAIRY-NOSED WOMBAT
Lasiorhinus latifrons
An inhabitant of central southern Australia, this wombat [illegible] in warrens [illegible]

RINGTAILS AND RELATIVES

This family consists of ringtail possums and the lemurlike greater glider. The Pseudocheiridae are all arboreal and are specialized leaf-eaters. They have an enlarged pouch at the start of the large intestine for fermentation of cellulose from their diet.

COMMON RINGTAIL
Pseudocheirus peregrinus
This agile marsupial lives in a wide range of habitats in eastern Australia and Tasmania. It has become a pest in New Zealand.

12–14 in
30–35 cm

12–16 in
31–40 cm

BRUSHY-TAILED RINGTAIL
Hemibelideus lemuroides
Found only in a small area of rain forest in northeast Queensland, Australia, this species of ringtail is nocturnal.

CUSCUS AND RELATIVES

The family Phalangeridae includes cuscuses, brushtail possums, and their relatives. Most members are arboreal, with an opposable thumb on the hind limbs and a prehensile tail. In cuscuses, part or all of the tail is naked, whereas in brushtail possums the tail has fur.

SULAWESI BEAR CUSCUS
Ailurops ursinus
The largest of the cuscuses, this species inhabits the canopy of temperate rain forest in Sulawesi and several other Indonesian islands.

large eyes assist sight at night

24 in
61 cm

14–26 in
35–65 cm

COMMON SPOTTED CUSCUS
Spilocuscus maculatus
This cuscus is sexually dimorphic (males and females look different) — only the male has spots. It lives in the rain forests of New Guinea and northeastern Australia.

strong, curved claws

furry tail

16–20 in
40–50 cm

MOUNTAIN BRUSHTAIL POSSUM
Trichosurus cunninghami
The mountain brushtail possum inhabits dense, wet forests in southeast Australia, typically living at altitudes above 1,000 ft (300 m).

13–23½ in
33–60 cm

CUSCUS
Phalanger sp.
Cuscuses of this genus live on New Guinea and nearby islands. They live at different altitudes to avoid competition with one another.

16 in
40 cm

SCALY-TAILED POSSUM
Wyulda squamicaudata
Found only in the Kimberley in northwest Australia, this nocturnal possum is solitary and bears just one young at a time.

GLIDING AND STRIPED POSSUMS

The Petauridae include striped possums and gliders, except the greater glider (left). Gliders have a thin, furred membrane between their fore and hind limbs. Striped possums emit strong smells and have an elongated fourth finger to probe for wood-boring beetles.

14–19 in
35–48 cm

GREATER GLIDER
Petauroides volans
The largest gliding marsupial, this species can travel distances of over 330 ft (100 m) between trees. It lives in eastern Australia.

grizzled, gray fur

11–15 in
28–38 cm

GREEN RINGTAIL
Pseudochirops archeri
Named for its thick, greenish fur, this solitary possum is found only in rain forest in the far north of Queensland, Australia.

prehensile tail

gray body with dark stripe along its back

9½–11 in
24–28 cm

STRIPED POSSUM
Dactylopsila trivirgata
Skunklike in appearance and odor, this possum is a nocturnal tree dweller from northeastern Queensland, Australia, and New Guinea.

6–6½ in
15–17 cm

LEADBEATER'S POSSUM
Gymnobelideus leadbeateri
Found in moist, high altitude forests in Victoria, Australia, this possum feeds on insects, and sap and gum from trees.

DAINTREE RIVER RINGTAIL POSSUM
Pseudochirulus cinereus
Resembling a lemur, this ringtail possum lives in the montane tropical rain forest in the Daintree River area in northeast Queensland, Australia.

14 in
35 cm

6–8½ in
15–21 cm

thick tail

slab-shaped tail

SUGAR GLIDER
Petaurus breviceps
Partial to the sweet sap of eucalyptus trees, the sugar glider is native to northeast Australia, New Guinea, and neighboring islands.

HONEY POSSUM

This diminutive species is the only member of the family Tarsipedidae. It has fewer teeth than other possums and a long, brush-covered tongue for probing flowers.

HONEY POSSUM
Tarsipes rostratus
Inhabiting heathland and woodland in southwest Australia, this possum is a specialized feeder on nectar and pollen.

PYGMY GLIDER

The family Acrobatidae contains just two species—the pygmy or feather-tailed glider and the feather-tailed possum. Both have tails fringed with rows of stiff hairs.

PYGMY GLIDER
Acrobates pygmaeus
This species is the smallest gliding marsupial. It lives in eastern Australian forests, where it feeds on nectar.

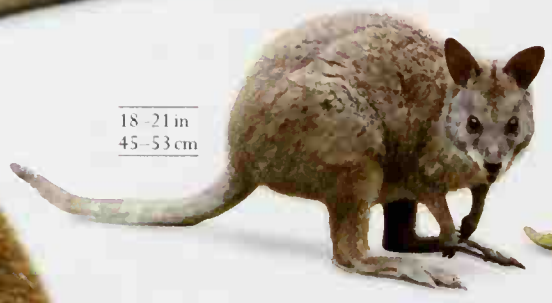
KANGAROOS AND RELATIVES

The kangaroos and wallabies of the family Macropodidae are medium to large animals, with long hind legs for jumping. The fourth and fifth toes of the hind feet are strong for load-bearing, while the second and third are reduced. The first toe has been lost in evolution.

COMMON WALLAROO
Macropus robustus
Widespread throughout most of mainland Australia, the common or hill wallaroo often seeks shade in rocky outcrops.

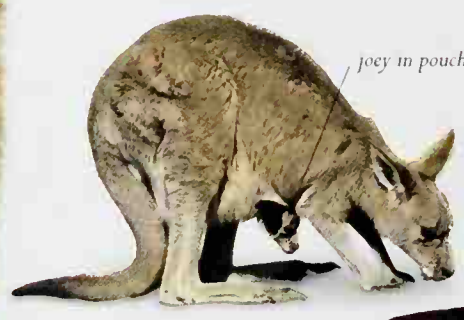
AGILE WALLABY
Macropus agilis
Unusual for wallabies, this species occurs in both Australia and New Guinea, where it inhabits grassland and open woodland.

RED-NECKED WALLABY
Macropus rufogriseus
This species lives in coastal forest and scrub in southeastern Australia, including the islands of Tasmania and the Bass Strait.

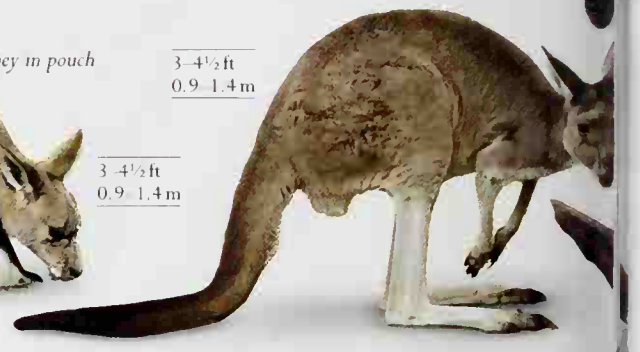


PARMA WALLABY
Macropus parma
Native to the mountains of the Great Dividing Range in Australia, the parma wallaby inhabits a range of forest habitats.

RED KANGAROO
Macropus rufus
The largest extant marsupial, this kangaroo is widespread in Australia, where it lives in savanna grassland and desert.



EASTERN GREY KANGAROO
Macropus giganteus
Widespread in eastern Australia, this species lives in dry woodland, scrub, and shrub. A subspecies is found in Tasmania.



WESTERN GREY KANGAROO
Macropus fuliginosus
The only kangaroo that does not reproduce using the method of delayed implantation of the embryo in the uterus, this species occurs in southern Australia, including Kangaroo Island.

POTOROOS

This family contains potoroos, bettongs, and rat kangaroos, small marsupials with many similarities to the larger Macropodidae. However, unlike them, the Potoroidae have a serrated premolar for tearing vegetation.

13½–15 in
34–38 cm

LONG-NOSED POTOROO
Potorous tridactylus
Inhabiting heath and forest in southeast Australia, this potoroo has strong, curved claws that help it to dig for underground fungi.

12–15 in
30–38 cm

BRUSH-TAILED BETTONG
Bettongia penicillata
This bettong lives in forest and grassland in southwest Australia. It has a prehensile tail that it uses for moving nesting material.

RAT-KANGAROO

The musky rat-kangaroo is the sole member of the family Hypsiprymnodontidae. It is relatively primitive; its hind foot has a first toe, which has been lost in other kangaroo species.

6–11 in
15–28 cm

MUSKY RAT-KANGAROO
Hypsiprymnodon moschatus
This diurnal species inhabits tropical rain forest in northern Queensland, Australia, where it forages for fallen fruits, seeds, and fungi.

28 in
70 cm

NORTHERN NAIL-TAILED WALLABY
Onychogalea unguifera
Also called the sandy nail-tailed wallaby, this medium-sized kangaroo occurs across northern Australia.

17–28 in
43–71 cm

BRIDLED NAIL-TAIL WALLABY
Onychogalea fraenata
This nocturnal wallaby was once thought to be extinct, the only remaining wild population is in a small area of Queensland, Australia.

RED-NECKED PADEMELON
Thylogale thetis
A forest wallaby from eastern Australia, this species ventures to the forest edge at night to feed on grass, leaves, and shoots.

11½–25 in
29–63 cm

muscular thighs

long, narrow sole of foot

26–34 in
66–85 cm

coarse, dark fur

12–15½ in
31–39 cm

RUFOUS HARE-WALLABY
Lagorchestes hirsutus
Previously inhabiting the Australian mainland, the mala or rufous hare-wallaby now exists in the wild on only two islands in Western Australia.

9½–12 in
24–30 cm

BROWN DORCOPSIS
Dorcopsis muelleri
This forest-dwelling kangaroo is endemic to the low-altitude rain forests of western New Guinea, and three offshore islands.

16–21½ in
40–54 cm

QUOKKA
Setonix brachyurus
Rare in mainland Australia, this small marsupial is found on Rottnest and Bald Islands, off the southwestern coast.

20–23½ in
50–60 cm

BRUSH-TAILED ROCK WALLABY
Petrogale penicillata
This resident of southeast Australia has roughened, padded hind feet that help it to grip when jumping in rocky habitats.

26–34 in
66–85 cm

coarse, dark fur

12–15½ in
31–39 cm

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16–21½ in
40–54 cm

QUOKKA
Setonix brachyurus
Rare in mainland Australia, this small marsupial is found on Rottnest and Bald Islands, off the southwestern coast.

20–32 in
51–81 cm

DORIA'S TREE KANGAROO
Dendrolagus dorianus
The heaviest of the tree-dwelling marsupials, Doria's tree kangaroo frequently descends to the ground. It lives in montane forest in New Guinea.

reddish brown upperparts

22–30 in
55–77 cm

GOODFELLOW'S TREE-KANGAROO
Dendrolagus goodfellowi
Also called the ornate tree-kangaroo, this species is native to the mountainous rain forests of New Guinea, where it feeds on leaves and fruit.

prehensile tail

19–26 in
48–65 cm

LUMHOLTZ'S TREE-KANGAROO
Dendrolagus lumholtzi
The smallest of the tree-kangaroos, this marsupial is found in the rain forests of north Queensland, Australia.

∨ BIG BOYS
Male red kangaroos are much larger than females, sometimes weighing twice as much. Only male red kangaroos are red; the females, known as blue fliers, have bluish gray fur all over. The males fight for access to mates, their battles taking the form of boxing matches.

velvety nose

glands in the chest produce scent, which male kangaroos rub on bushes to assert their dominance

kangaroos lick their wrists when hot—this cools the blood close to the skin

elastic tendon stores energy when the leg is flexed, and releases it to power the next hop

RED KANGAROO
Macropus rufus

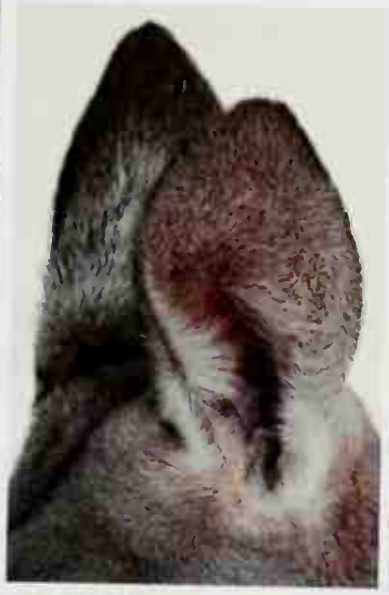
Kangaroos evolved in Australia, filling the niche occupied elsewhere by grazing animals such as antelope. In common with those species, kangaroos have a big stomach to take in large quantities of grass. Living out in the open is risky for all herbivores, and kangaroos share with antelope a number of adaptations for avoiding predators. They live in herds (called mobs), have sharp senses, are tall enough to scan their surroundings for danger, and possess a wonderful turn of speed. The red is the largest and swiftest kangaroo, able to hop at more than 30 miles (50 km) an hour. Only the female has a pouch, in which she carries her young—known as a joey—for the first seven months of its life. Red kangaroos are well adapted to drought—they are able to eat scrubby saltbush, which is toxic to other animals.

SIZE 3¼–5¼ ft (1–1.6 m)
HABITAT Scrubland, desert
DISTRIBUTION Australia
DIET Herbivorous

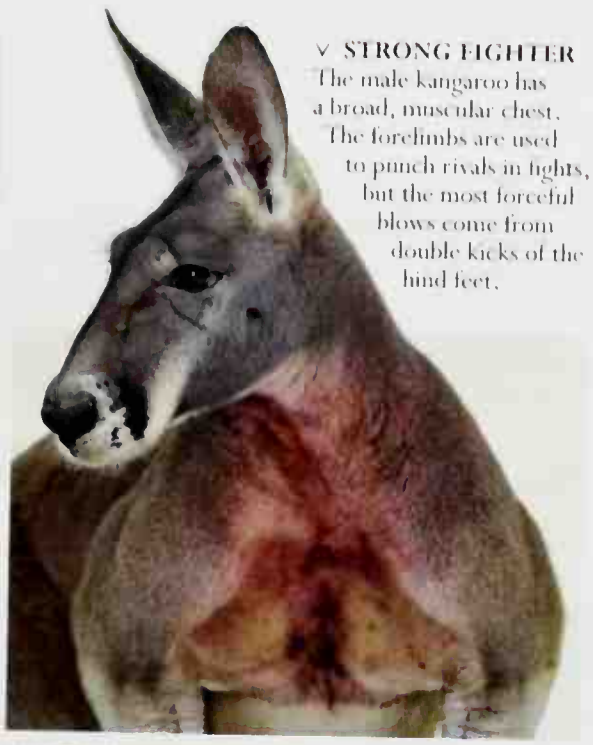
tail acts as a counterbalance when hopping, and as a supportive fifth limb when standing still

> EARS
The ears are large and sensitive, and can be swiveled in different directions to focus on sounds that might mean danger is approaching.

< EYE
The eyes are widely spaced toward the sides of the head, giving a very wide field of vision. This aids the kangaroo's awareness of predators.



^ CLAWS
The feet have surprisingly sharp claws. These provide grip when hopping, but also serve as weapons, and as combs for grooming.



v STRONG FIGHTER
The male kangaroo has a broad, muscular chest. The forelimbs are used to punch rivals in fights, but the most forceful blows come from double kicks of the hind feet.

< v HIND FOOT
The scientific name *Macropus* literally means "big foot." Each hind foot has four toes: an outer, weight-bearing pair, and an inner pair used for grooming.

^ HOPPING
Red kangaroos hop on their enormous hind legs with apparently effortless grace. They are able to cover up to 30 ft (9 m) in a single bound.

SENGIS

Formerly known as elephant-shrews, sengis form a single family. They are superficially similar to the true shrews, although they are not related.

Distinguished by an elongated, flexible snout, sengis are small, with long legs and tail. They move either on all fours or, especially if they need to move fast, by hopping. Sengis live in pairs within a defined area, although there is little interaction between the partners. Males and females even sometimes make separate nests, each defending the jointly held territory against intruders of its own sex. Active mostly by day, many sengis maintain a network of cleared paths around their territory, which they patrol for prey and use as quick escape routes if threatened.

Found only in Africa, sengis occupy a range of habitats, from forests and savanna to extremely arid deserts. Some take shelter in rock crevices or nests of dried leaves, while the larger species dig out shallow burrows.

Sengis are primarily insectivorous, although some species take spiders and worms. They use their sensitive noses to root on the ground and under leaf litter for food, extending their long tongues to scoop up their prey.

ACTIVE YOUNG

Depending on species, a pair of sengis may breed several times during the year. Litters are small, numbering between one and three young, which are well developed at birth and rapidly become active.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	MACROSCELIDEA
FAMILIES	1
SPECIES	15

DEBATE

AN ORDER OF THEIR OWN

The classification of sengis has been much debated. Previously, they were linked with shrews and hedgehogs, or thought to belong in the order Lagomorpha—which includes hares and rabbits—or to be distant relatives of the hoofed mammals. Now they have their own order: Macroscelidea.

SENGIS

Found only in Africa, the Macroscelididae occur in a wide range of habitats, from deserts to mountains to forests. Largely insectivorous, sengis (or elephant-shrews) use their elongated, movable snout to search for prey, which they flick into the mouth with the help of their tongue.

BUSHVELD SENGI
Elephantulus intufi
Widespread in arid shrubland in southern Africa, this sengi occupies large territories, which it defends vigorously against rivals of the same sex.

3½–4¾ in
9–11 cm

4¾–5½ in
12–14 cm

WESTERN ROCK SENGI
Elephantulus rupestris
Inhabiting rocky shrubland in southwest Africa, this species is active by day, leaving the shade of a rock crevice to foray for food.

4¾–5 in
11–12.5 cm

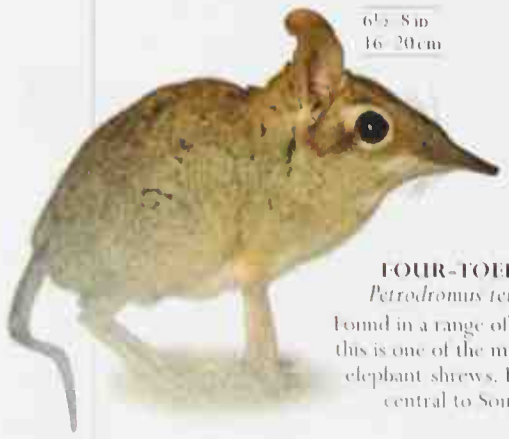
NORTH AFRICAN SENGI
Elephantulus rozeti
The only North African elephant-shrew, this desert species slaps its very long tail and drums its feet when alarmed.

3½–5½ in
9–14 cm

RUFOUS SENGI
Elephantulus rufescens
Found in southern and eastern Africa, this sengi has long, sandy reddish fur and a tail as long as its head and body.

DUSKY-FOOTED SENGI
Elephantulus fuscipes
From hot, dry grassland in central Africa, this poorly known species may belong to a different genus of sengis.

4–4¾ in
10–12 cm



6½–8 in
16–20 cm

FOUR-TOED SENGI
Petrodromus tetradactylus
Found in a range of moist habitats, this is one of the most widespread elephant-shrews. It occurs from central to South Africa.

9–12½ in
23–32 cm

BLACK AND RUFOUS SENGI
Rhynchocyon petersi
This giant elephant-shrew inhabits the coastal forests of East Africa. Its orange foreparts graduate through deep red to black on the rump.

4–4¾ in
10–12 cm

ROUND-EARED SENGI
Macroscelides proboscideus
A medium-sized sengi, this southern African species occupies some of the world's driest habitats. Strictly monogamous, males strongly guard their mates.

TENRECS AND GOLDEN MOLES

Two families make up the order known as Afrosoricida. The golden moles are exclusively burrowers, but tenrecs have evolved into a range of niches.

Most species in this order are native to mainland Africa, with tenrecs additionally found on Madagascar. Golden moles are all very similar in appearance, with a cylindrical body and other anatomical adaptations to suit their burrowing lifestyle. In contrast, tenrecs display diverse characteristics that reflect the wide range of habitats that they occupy. Various species of tenrecs are found in tropical forests, where they may be terrestrial or semiarboreal; others are aquatic and otterlike, living in streams and rivers; and there are also burrowing tenrecs. Until recently, tenrecs and golden moles were classified with true moles, shrews, and hedgehogs because of their largely insectivorous diet and often similar appearance. It is now known that the order Afrosoricida evolved independently and is most closely related to the elephants, hyraxes, and sirenians.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	AFROSORICIDA
FAMILIES	2
SPECIES	About 51

UNUSUAL FEATURES

Tenrecs and golden moles have features once considered primitive but now recognized as adaptations to harsh environments. Such features include a low metabolic rate and body temperature. These mammals also have the ability to enter a state of torpor—for up to three days—to save energy in cold conditions, and possess highly efficient kidneys, which reduce the need to drink water.

A Grant's golden mole feasts on a locust. At night it forages for food on the surface, feeding mainly on termites.

GOLDEN MOLES

These moles resemble both true moles (Talpidae) from Europe, Asia, and North America, and marsupial moles (Notoryctemorphia) from Australia, as all have similar burrowing habits. The Chrysochloridae from southern Africa have short legs with powerful digging claws, dense fur that repels moisture, and toughened skin, especially on the head. They have nonfunctional eyes covered with skin, and lack external ears.

4–5 in
10–13 cm

JULIANA'S GOLDEN MOLE
Neamblysomus julianae
Unique to the dry highlands of South Africa, typically in sandy soils, this species frequents well-irrigated gardens within its range.

soft, dense glossy fur
ribbed ears tuck well backward
eyes covered with thick layer of skin
leathery pad prevents warmth and soil burrowing

4–4½ in
10–11 cm

CAPE GOLDEN MOLE
Chrysochloris asiatica
Although secretive, this is a common species in parts of South Africa. It uses the enlarged second toe on its front feet for digging.

3–3½ in
7.5–8.5 cm

HOTTENTOT GOLDEN MOLE
Amblysomus hottentotus
This golden mole inhabits tunnel systems up to 655 ft (200 m) long, using the large second and third toes on its front feet for digging.

4½–5½ in
11.5–14 cm

GRANT'S DESERT GOLDEN MOLE
Eremitalpa granti
Inhabiting the southwest African coastal dunes, one of the world's driest habitats, this species "swims" through sand rather than building tunnels.

TENRECS

From Africa and Madagascar, tenrecs have diverse body forms, resembling the unrelated shrews, mice, hedgehogs, and otters. They range in weight from 3/16 oz (5 g) to more than 2¼ lb (1 kg). Largely nocturnal and with poor eyesight, these insectivores use their sensitive whiskers to locate food.

5½–7½ in
14–19 cm

LOWLAND STREAKED TENREC
Hemicentetes semispinosus
A tail-less tenrec, the coarse, spiny coat of this species is distinctively two-tone—black, with yellow stripes and crown bristles.

10–15½ in
26–39 cm

COMMON TENREC
Tenrec ecaudatus
A large terrestrial tenrec, with red-brown fur and spines along the body, the females have up to 29 teats, more than any other mammal.

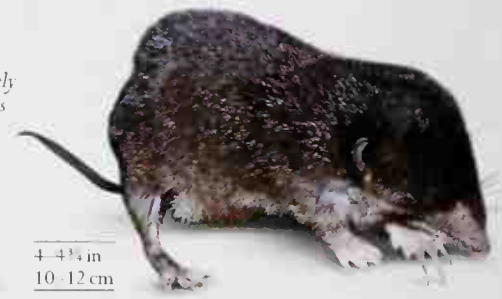
LESSER HEDGEHOG TENREC
Echinops telfairi
Its hairs modified into spines, this species bears a remarkable resemblance to a true hedgehog, sharing its defense behavior of rolling into a ball.

4–6 in
10–15 cm

white-tipped spines on back

moderately large ears

sharp claws



4–4¾ in
10–12 cm

RICE TENREC
Oryzorictes sp.
A burrower with well-developed forelimbs, long claws, and small eyes and ears, this tenrec can become very numerous in marshes and rice paddies.

6–8½ in
15–21 cm

GREATER HEDGEHOG TENREC
Setifer setosus
Widespread throughout Madagascar, even in urban habitats, this species has a diverse diet, from insects, earthworms, and carrion to fruit.

AARDVARK

The only species in the Orycteropodidae, the aardvark is adapted for digging. It has an arched back, thick skin, long ears, and a tubular snout.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	TUBULIDENTATA
FAMILIES	1
SPECIES	1

The aardvark's toes (four on the front feet and five on the hind) each have a flattened nail used to dig burrows and excavate insect nests, which it detects through its keen sense of smell.

It uses its long, thin tongue to catch huge numbers of insects. Its teeth are very unusual, and are one of the main reasons for it being classified in its own order. A young aardvark is born with incisors and canines at the front of the jaw, but when these fall out they are not replaced. The rear teeth lack enamel and grow through life; they are columnar and rootless, and unlike those of any other mammal.

AARDVARK

Inhabiting savanna and bushland in sub-Saharan Africa, aardvarks are solitary and nocturnal. Powerful front legs with flattened claws are used to dig into the nests of ants and termites for food.

AARDVARK
Orycteropus afer
The yellowish skin of the aardvark is often stained red by soil, in which it burrows and forages. It also has a sparse covering of bristly hairs.

3¼–4¼ ft
1–1.3 m

hair lighter colored on body

long, blunt, shovel-shaped claws

DUGONG AND MANATEES

A small order of fully aquatic herbivores, sirenians inhabit a range of tropical habitats, from swamps and rivers to marine wetlands and coastal waters.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	SIRENIA
FAMILIES	2
SPECIES	4

Also known as sea cows, sirenians are supremely adapted to an aquatic way of life. Their front legs are paddlelike and adapted for steering; the hind legs are not visible, being restricted to two small remnant bones floating in the muscle. The body is therefore streamlined, and the flattened tail provides propulsion. A layer of blubber below its skin provides insulation, but to help counteract its natural buoyancy, the bones are dense and the lungs and diaphragm extend for the full length of the spine. The result is a hydrodynamic body, albeit rather slow-moving, capable of fine adjustments to shift its position in the water. All four species are considered to be at risk of extinction.

DUGONG

There is only one species in the Dugongidae. Slow-moving, marine herbivores, dugongs graze on submerged seagrass beds, using the downturned muscular snout to uproot food.

8¼–9¾ ft
2.5–3 m

DUGONG
Dugong dugon
From the Indo-Pacific region, especially around Australia, the dugong's cylindrical body has no dorsal fin or hind limbs. The tail has flukes.

MANATEES

With shorter snouts than dugongs, the Trichechidae also differ in the shape of their tail, which is paddle-shaped rather than fluked. Rather sluggish, they spend much of the day sleeping under water, surfacing every 20 minutes to breathe.

FLORIDA MANATEE
Trichechus manatus latirostris
The largest living sirenian, the Florida manatee inhabits both freshwater and coastal waters of the southeastern USA. It feeds on aquatic plants.

9¾–15 ft
3–4.6 m

AMAZONIAN MANATEE
Trichechus inunguis
A freshwater manatee from the Amazon Basin, this species usually has a characteristic white chest patch.

6½–9¾ ft
2–2.8 m

9¾–13 ft
3–4 m

ANTILLEAN MANATEE
Trichechus manatus manatus
Ranging from Mexico to Brazil, this manatee is smaller and more likely to be found farther from the shore than the Florida subspecies.

HYRAXES

Furry and rotund, modern hyraxes belong to the only extant family in the order Hyracoidea. Hyraxes were once the primary terrestrial herbivores in the Old World. Now just four species remain.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	HYRACOIDEA
FAMILIES	1
SPECIES	4

Widely represented in the fossil record of Asia, Africa, and Europe, some extinct species of hyrax were over three feet in height.

Unlike most browsing and grazing animals, hyraxes use their cheek teeth (rather than incisors) to slice vegetation, before chewing it. With a relatively indigestible diet, they have a complex stomach in which bacteria break down tough plant matter.

With a number of primitive mammalian features, such as poor control of their internal body temperature, hyraxes show several affinities with elephants: their upper incisor teeth are often extended into short tusks, their soles have sensitive pads, and they have high brain function.

HYRAXES

The Procaviidae are rotund, short-tailed herbivores from Africa and the Middle East. Hyraxes are often seen basking in the sun, and huddling together in groups for warmth. They will also seek shade if too hot. Behaving in this way provides hyraxes with an effective means of thermoregulation.

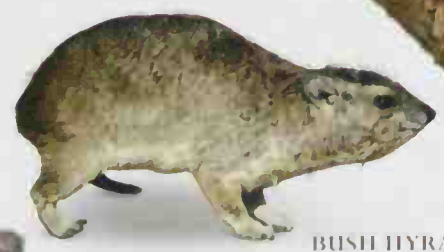
12½–23½ in
32–60 cm

long, silky fur

short snout

WESTERN TREE HYRAX
Dendrohyrax dorsalis
A dark, semiarboreal hyrax from West and central Africa, this species has a distinctive white patch on its lower back and rump.

12–15 in
30–38 cm



BUSH HYRAX
Heterohyrax brucei
There are 25 subspecies of bush hyrax in rocky habitats across Africa. It feeds on grass and fruit, and also catches and eats small vertebrates.

12–28 in
30–70 cm

SOUTHERN TREE HYRAX
Dendrohyrax arboreus
An able climber from southern Africa, usually inhabiting hollow trees, this hyrax is known for its shrieking territorial calls at night.

18–22 in
45–55 cm

ROCK HYRAX
Procavia capensis
From Africa and the Middle East, this colonial hyrax basks for long periods. Moist, rubbery foot pads provide grip on smooth rocky surfaces.

ELEPHANTS

Largest of all land mammals, elephants are distinguished by their colossal bulk, long flexible trunk, large ears, and curving ivory tusks.

The only members of the Proboscidea, elephants inhabit grassland and forest in tropical Africa and Asia. Sometimes weighing more than five tons, elephants have a modified skeleton to bear their weight. The limb bones are extremely stout, and the toes are splayed around a pad of connective tissue. This large frame needs vast amounts of food and elephants eat for up to 16 hours a day, consuming up to 550 lb (250 kg) of vegetation.

EARS, NOSE, AND MOUTH

The elephant's muscular trunk, a fusion of the nose and upper lip, is remarkably versatile and is able to grasp morsels of food. It can also draw in water and serve as a snorkel when swimming. Sensory organs in the trunk pick up scents and vibrations, aiding communication. An elephant's large ears are also used for communication and when spread out are a sign of aggression. Constant flapping of the ears helps an elephant lose heat. Tusks are incisor teeth that grow continually. They are used to dig for roots and salt, clear pathways, and mark territories.

SOCIAL STRUCTURES

Male and female elephants have different social behavior. Females form herds of related cows and their calves, led by an elderly matriarch. Bull elephants form short-term associations, but will fight with any intruding rival during the breeding season.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	PROBOSCIDEA
FAMILIES	1
SPECIES	3

DEBATE

TWO SPECIES OR ONE?

Most zoologists recognize two species of African elephant, the savanna elephant and the smaller forest elephant. Physical differences between the species are reflected in their DNA, but even so, the two types may interbreed where their ranges overlap. Because of this, many conservation bodies still regard all African elephants a single species.

ELEPHANTS

The extinct mammoths and the living elephants form a family—the Elephantidae—of large herbivores, with a long trunk, large ears, thick skin, and tusks. The trunk is used in feeding, drinking, bathing, and social interactions. They make many sounds, from trumpeting to subsonic rumblings, enabling them to communicate over long distances.

6½–12 ft
2–3.6 m

semicircular toenails

ASIATIC ELEPHANT
Elephas maximus

Domesticated for forest operations and ceremonial use, this species has smaller ears and a more arched back than African species. Females usually lack tusks, as do some males.

9¾–12 ft
3–3.6 m

large ears

long, curved tusks

AFRICAN SAVANNA ELEPHANT
Laxadanta africana

The largest living land animal, this elephant has a large head and ears. Both sexes have well-developed, curved tusks.

6½–8¼ ft
2–2.5 m

muscular trunk projections

AFRICAN FOREST ELEPHANT
Laxadanta cyclatis

With five toenails on the forelimbs and four on the hind limbs, this small elephant with straight tusks from the forests of Africa resembles the Asiatic elephant.

ARMADILLOS

Recognizable by their armored shell—unique among mammals—armadillos occur in various shapes, sizes, and colors. All are native to the Americas.

These animals, sole members of the order Cingulata, range across a variety of habitats, feeding primarily on insects and other invertebrates. Despite having short legs, armadillos can run quickly and burrow with their strong claws to avoid predators. Their main defense consists of a bony carapace, covered with horny plates, across their upperparts. In most species, there are rigid shields over the shoulders and hips, with a varying number of bands separated by flexible skin covering the back and flanks. This allows some species to roll into a ball to protect the vulnerable, furry underparts. Armadillos have few natural predators. Despite the threats from human hunters and habitat loss, the range of some armadillo species is expanding.

Although their armor is heavy, armadillos are effective swimmers. By inflating the stomach and intestines with air, they can increase their buoyancy and cross small bodies of water. They can also remain underwater for several minutes, another mechanism for avoiding predation.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	CINGULATA
FAMILIES	1
SPECIES	21

HABITS

Most species of armadillo are nocturnal, though they occasionally emerge during the day as well. These animals are largely solitary, associating with one another only during the mating season. Males sometimes display aggression toward rivals.

Contrary to popular belief, not all armadillos can roll into a ball in defense—only species of the genus *Tolypeutes* can.

ARMADILLOS

The only surviving family in their order, the Dasypodidae are found in the Americas. Covered with bony plates across their upperparts, they use their sharp claws to dig for invertebrates and to excavate burrows. Of the 20 or so species, some are able to roll into a ball when threatened, in order to protect their vulnerable, soft, furry underparts.

LONG-NOSED ARMADILLO
Dasypus sp.
The six species of this genus inhabit shaded, rocky areas. Unlike other armadillos, they have sparse, yellowish fur, mainly on their bellies.

ANDEAN HAIRY ARMADILLO
Chaetophractus nationi
Unusual in having copious hair between its scales, this inhabits high-altitude South American grasslands. It is hunted for its meat and shell.

LARGER HAIRY ARMADILLO
Chaetophractus villosus
From arid habitats in southern South America, this species has long, coarse hairs between the 18 or so plates of protective armor across its back.

PICHI
Zaedyus pichiy
A small, dark armadillo with thick dorsal plates, this species wedges itself into its burrow when threatened, presenting its jagged scales for defense.

SIX-BANDED ARMADILLO
Euphractus sexcinctus
More active by day than most armadillos, this brownish yellow species forages in grassland and forest, eating plant and animal matter.

PINK FAIRY ARMADILLO
Chlamyphorus truncatus
This tiny armadillo from central Argentina is mainly subterranean, "swimming" through loose sand; its head is shielded to reduce abrasion.

GIANT ARMADILLO
Priodontes maximus
The largest armadillo, this species has tough armor and uses its long, curved third front claw to dig for food and in defense.

NORTHERN NAKED-TAILED ARMADILLO
Cabassous centralis
The protective plates of this Central and South American armadillo do not extend to its tail. It relies mainly on dense cover to avoid predators.

SIX-BANDED ARMADILLO

Euphractus sexcinctus

Despite its name, this species of armadillo may have anything from six to eight armored bands around its middle. The upper part of the animal's body is covered by a sturdy carapace, which is made up of plates of bone, topped with a thin covering of horny material, and is embedded in the armadillo's skin. The bands act as joints in the carapace, giving the animal flexibility, although it is unable to curl completely into a ball like some other species. The six-banded armadillo is diurnal, spending the daylight hours trundling around its home range in search of food. It has a varied diet, ranging from roots and shoots to invertebrates and carrion.

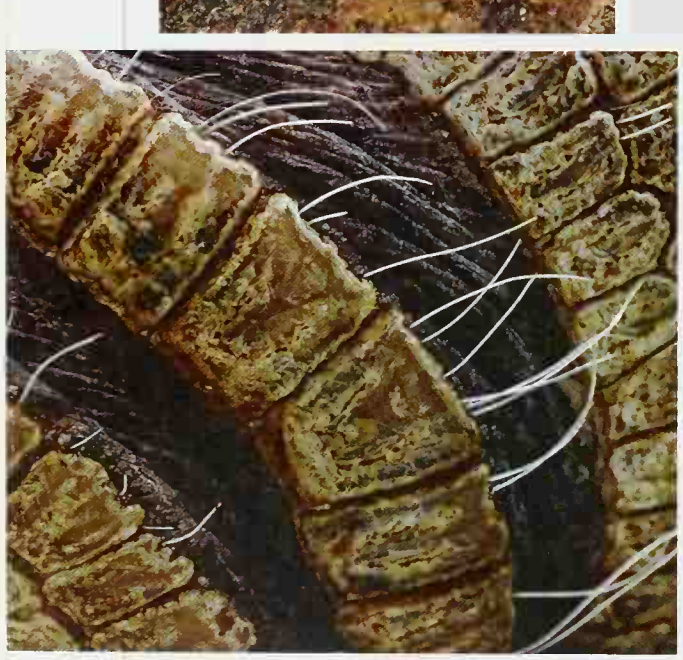
SIZE 16–19½ in (40–49 cm)
HABITAT Forest
DISTRIBUTION South America, mainly south of Amazon Basin
DIET Omnivorous

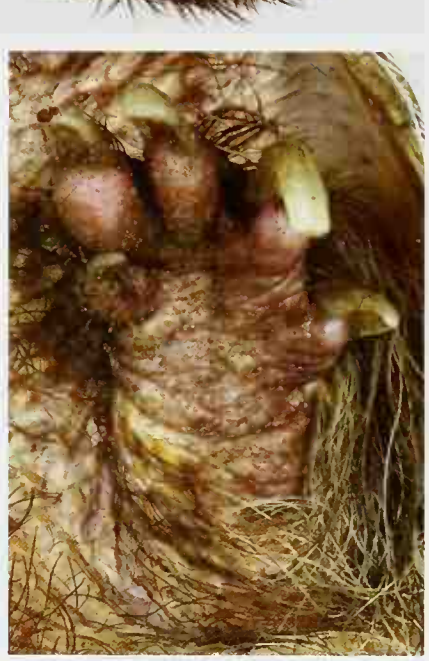
< SHIELDED EYE
The armadillo's eyes are protected by the headshield at the expense of a slightly restricted field of vision. Because it has poor eyesight anyway, this makes little difference.

< NOSE
Armadillos have an acute sense of smell. They sniff and snuffle their way to most meals, and can easily detect food buried in the soil.

head is narrow and pointed and protected by a shield made of fused bony plates

< STRONG LEGS
The armadillo has short but powerful legs. When digging, soil loosened by the front feet is kicked out of the hole by the hind feet.





^ HAIRY SKIN
The bony carapace is interrupted by six to eight bands, which are separated by flexible skin. Long, bristly hairs sprout from between the bands—this is one of the hairy armadillos.

TAIL >
Glands at the base of the armadillo's tail release scent through small holes in the armor plates. The scent marks the armadillo's territory.

^ CLAWS
Long, strong claws allow the armadillo to dig rapidly into hard ground. In a matter of minutes it is able to excavate a trench deep enough to bury itself in.

ARMORED DIGGER

The distinctive carapace offers some defense against predators, although armadillos prefer to run away if possible. When digging, the carapace protects the skin from abrasion. Armadillos dig to find food (both plant and animal matter), and to make burrows in which they live or briefly hide themselves.

parts of the body not covered in bony plates sprout a sparse coat of long hairs

SLOTHS AND ANTEATERS

Although very different in form and habits, sloths and anteaters have one characteristic in common: they share a lack of normal mammalian dentition.

With just one exception, members of this order, the Pilosa, are largely arboreal creatures: only the giant anteater is terrestrial. They are all native to Central and South America.

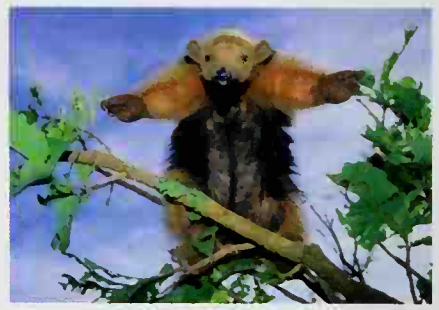
The two anteater families feed on ants, termites, and other insects. Anteaters have no teeth at all, relying on their long sticky tongue to capture insects, which are then crushed in the mouth before being swallowed.

The slow-moving sloths are herbivorous. They have no incisors or canines, but instead have a number of cylindrical, rootless teeth, used to grind up their food. A sloth may take about a month to completely digest a meal, as the fibrous leaf matter passes slowly through several stomach compartments and is broken down by bacteria.

ARBOREAL LIFE

The long, prehensile tails of the arboreal anteaters allow them to lead a more active lifestyle than the sloths. On the ground, all the arboreal species move only with difficulty, although some are excellent swimmers. When walking, their mobility is restricted by their enlarged, curved claws, which the sloths use like hooks to hang from branches. Anteaters have enlarged claws only on their front feet. These claws are used to tear open insect nests in search of food, and are formidable defense weapons.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	PILOSA
FAMILIES	4
SPECIES	10



To defend themselves members of the genus *Tamandua* stand up on their hind legs and lash out with their powerful front limbs.

THREE-TOED SLOTHS

Generally smaller and slower moving than two-toed sloths, the arboreal and mostly nocturnal Bradypodidae have three toes on each foot, bearing long, curved claws that help them hang from branches. Their long, shaggy fur has a green tinge, due to algae growing on it.

MANED SLOTH
Bradypus torquatus
This small Brazilian sloth has long, dark fur—especially around its head and neck—which often harbors algae, ticks, and moths.

BROWN-THROATED SLOTH
Bradypus variegatus
An inhabitant of Central and South American forests, this sloth is the most widespread in its family. The female attracts her mate with a shrill scream.

PALE-THROATED SLOTH
Bradypus tridactylus
Found in the rain forests of South America, this species has an unusual appearance, with almost no tail or external ears.

TWO-TOED SLOTHS

Unlike three-toed sloths, the Megalonychidae have only two toes on their forefeet, a more prominent snout, and no tail. Similarly arboreal and mainly nocturnal, they usually descend from trees head first.

SOUTHERN TWO-TOED SLOTH
Choloepus didactylus
This large herbivore from South America swims well, even crossing rivers. Its main predators are large raptors, such as harpy eagles.

SILKY ANTEATERS

The Cyclopedidae, though well-represented in the fossil record, has only one extant species. Large, curved front claws and a prehensile tail help the silky anteater live in trees, where it nests in holes. It feeds on ants and termites.

SILKY ANTEATER
Cyclopes didactylus
Arboreal, nocturnal, and slow moving, this is the smallest anteater. When threatened, its sharp claws provide an effective defense against predators.

GIANT ANTEATER AND RELATIVES

Native to Central and South America, the Myrmecophagidae have elongated snouts and long tongues. They use their powerful claws to rip open termite mounds and ant hills. Lacking teeth, they catch insects with their sticky saliva and spine-covered tongues.

COLLARED ANTEATER
Tamandua tetradactyla
This solitary species has a prehensile tail. Only the southern populations in South America have black markings.

GIANT ANTEATER
Myrmecophaga tridactyla
The largest anteater, with a tail almost as long as its body, this species uses its long, sticky tongue to catch up to 30,000 insects a day.

RABBITS, HARES, AND PIKAS

Two herbivorous families make up the order known as Lagomorpha. Their apparent similarities to rodents result from adaptation to a common lifestyle.

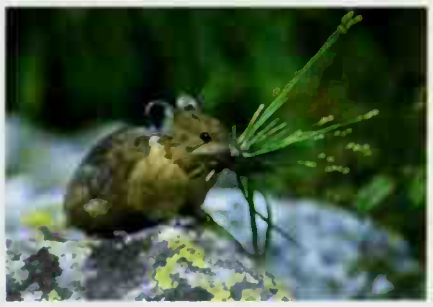
These species occupy a variety of habitats, from tropical forest to Arctic tundra. All are terrestrial herbivores or browsers. They are gnawing animals and share the diet of many rodents. Like those of rodents, the teeth of rabbits, hares, and pikas continue to grow throughout life—they are worn down by chewing. However, there are fundamental differences between the groups: rabbits and their relatives have four incisors in the upper jaw, while rodents have only two.

Relying on food that is relatively slow to break down, these animals have a modified digestive system. They produce two types of feces: moist pellets, which are eaten to gain further nutrients from the food, and dry pellets passed as waste.

ESCAPING PREDATORS

Pikas, the most rodentlike species in this order, take refuge from predators in burrows and crevices after raising the alarm with a whistle. Rabbits and hares, in contrast, have long ears to detect danger and powerful limbs to flee from predators. These animals have large eyes positioned high on each side of the head to provide almost 360-degree vision. When a predator is observed, hares drum their hind legs on the ground in warning.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	LAGOMORPHA
FAMILIES	3
SPECIES	92



To survive the winter, the pika collects various plants, creates a hay pile of dried food, and stores it in its den.

RABBITS AND HARES

Native across much of the world, the Leporidae have long, movable ears and enlarged hind legs to detect and escape predators. Large eyes reflect their mainly nocturnal habits. Rabbits often inhabit permanent burrow systems, whereas the more solitary hares make only transitory shelters.

EUROPEAN RABBIT
Oryctolagus cuniculus
Native to the Iberian peninsula, this species has been introduced for meat and fur worldwide, with devastating effects on local habitats and wildlife.

DWARF RABBIT
Oryctolagus cuniculus
One of the smallest breeds, the dwarf rabbit occurs in many colors and patterns. Its rounded face and small ears make it a popular pet.

CREAM ANGORA RABBIT
Oryctolagus cuniculus
Valued for its long, soft hair, which is spun into yarn, this breed originates from Anatolia (in modern-day Turkey).

LOP-EARED RABBIT
Oryctolagus cuniculus
One of the oldest domesticated forms, this type has long, lop-eared (floppy) ears. There is variation in both color and size.

» RABBITS AND HARES

9–22 in
22–55 cm

COTTONTAIL
Sylvilagus sp.
Distributed across the Americas, most of the 17 species in this genus have stubby white tails and nest above ground, not in burrows.

MARSH RABBIT
Sylvilagus palustris
16½–17½ in
42–44 cm
Inhabiting wetlands of North America, this species is a strong swimmer. It walks instead of hopping, unlike most of its relatives.

20–28 in
50–70 cm

EUROPEAN HARE
Lepus europaeus
A grazer in summer and a browser of bark and buds in winter, this hare is shy and solitary, except during its springtime "boxing" courtship. Females fight off males until ready to mate.

22–26 in
56–66 cm

WHITE-TAILED JACKRABBIT
Lepus townsendii
This species ranges extensively across western North America. The northern population turns white in winter, while the southern animals develop whitish patches only on their flanks.

14–18 in
36–46 cm

SNOWSHOE HARE
Lepus americanus
Adapted to harsh North American winters, this species has a white winter coat for camouflage, and large hind feet to allow movement on soft snow.

22–28 in
55–70 cm

ARCTIC HARE
Lepus arcticus
Adapted to polar and mountainous areas, this hare survives with thick fur that turns white in winter, and by digging holes in the snow for shelter.

18–23½ in
45–60 cm

ANTELOPE JACKRABBIT
Lepus alleni
Very long ears and insulated, reflective fur help this large hare to keep cool in its desert grassland habitats in Mexico.

18–26 in
46–65 cm

MOUNTAIN HARE
Lepus timidus
From polar regions and mountains in Europe and Asia, this hare has a white winter coat and a tail that stays white all year round.

20½–23½ in
52–60 cm

CAPE HARE
Lepus capensis
Common in open habitats of Africa and the Middle East, this species is very similar to the closely related European hare.

18½–25 in
47–63 cm

BLACK-TAILED JACKRABBIT
Lepus californicus
Widespread on western North American prairies and farmland, this species is prone to huge local fluctuations. It has a black tail and black ear-tips.

PIKAS

The Ochotonidae are small herbivores that live in rocky mountain sides and open steppes in North America and Asia. Alert to predators, they produce high-pitched alarm calls as they run for cover in crevices and burrows.

6½–8½ in
16–21 cm

AMERICAN PIKA
Ochotona princeps
This North American montane scree dweller dries food piles in the sun, and stores them in its den for the winter.

RODENTS

Ranging from tiny mice to animals the size of a pig, rodents live in almost every habitat type. They make up nearly half of all mammal species.

Members of the order Rodentia are distinguished by having a pair of prominent upper and lower incisor teeth (often orange or yellow in color), which continue to grow throughout life. Gnawing—a characteristic behavior of all rodents—wears the teeth away at the same rate as they grow. Rodents have no canines, just a long space between the incisors and the three or four cheek teeth in each jaw. The scientific classification of rodents is also based on other features of their teeth and jaws that are not visible externally.

SPECIES DIVERSITY

To suit their various lifestyles, rodents often have special adaptations such as webbed toes, big ears, or long hind feet for a bounding gait. Some rodents burrow, others live in trees or in the water, but none live in the sea. Many species inhabit desert regions, where they may never drink, deriving all the water they need from food.

THE IMPACT OF RODENTS

Several rodent species carry fatal diseases that have killed millions of people. Others consume or contaminate huge quantities of stored food meant for humans. The house mouse has become the world's most widespread wild mammal through its close association with humans. This species inhabits every continent, including Antarctica, even surviving in mines and cold stores. Some rodents cause damage to crops or trees, or burrow in inconvenient places. Beavers can transform entire habitats, affecting hundreds of other animal and plant species.

On the positive side, rodents are a vital food source for predatory animals and, in some countries, for humans as well. Many small rodents, such as hamsters, are specially bred as pets.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	RODENTIA
FAMILIES	33
SPECIES	2,277

DEBATE

RODENT ORGANIZATION

The huge diversity of species in the order Rodentia makes the task of classifying them complicated. With 33 families of modern rodents to organize, experts in zoological classification have divided them into two subgroups, according to differences in their skulls, teeth, and jaws. The Sciurognathi (squirrel-jaws) are globally widespread, and include all squirrels, beavers, and mouselike rodents. The Hystricognathi (porcupine-jaws) includes the cavies, porcupines, chinchillas, and the capybara, and these are mostly restricted to the Southern Hemisphere and the tropics.

MOUNTAIN BEAVER

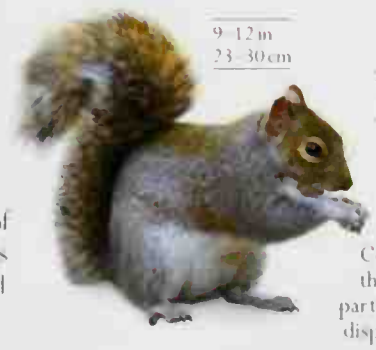
Only one species of the once widespread family Aplodontiidae has survived into modern times. The mountain beaver, or sewellel, lives in burrows in the damp forests and plantations of western North America.

MOUNTAIN BEAVER
Aplodontia rufa
This most primitive type of living rodent inhabits forested coastal mountains of western Canada and the USA.

SQUIRRELS AND CHIPMUNKS

Occurring almost everywhere, except in the polar regions, Australia, and the Sahara Desert, members of the family Sciuridae range from tropical rain forests to Arctic tundra, and from the tops of trees to underground tunnels. This family includes typical bushy-tailed tree squirrels, many species of burrow-digging ground squirrels, chipmunks, and marmots. They feed mainly on nuts and seeds.

EURASIAN RED SQUIRREL
Sciurus vulgaris
When this squirrel molts into its summer coat, the long hairs on its ears are lost.



GRAY SQUIRREL
Sciurus carolinensis
Common in the eastern USA, this species was introduced to parts of Europe, where it is slowly displacing the native red squirrel.

AMERICAN RED SQUIRREL
Tamiasciurus hudsonicus
The chattering calls and sharp barks of the red squirrel are common sounds of coniferous woodlands in Canada and the northern USA.

SOUTHERN FLYING SQUIRREL
Glaucomys volans
A strictly nocturnal native of the eastern USA, this squirrel lives in tree holes and attics, often in groups during winter.

PALE GIANT SQUIRREL
Ratufa affinis
Of the four species of giant squirrel, this species inhabits the forests of the Malay Peninsula, Borneo, and Sumatra.

GRIZZLED GIANT SQUIRREL
Ratufa macroura
One of the world's largest tree squirrels, this species occurs in southern India and Sri Lanka. It eats fruits, flowers, and insects.

PREVOST'S SQUIRREL
Callosciurus prevostii
There are 15 species of these tricolored squirrels. Prevost's is found in Malaysia, Borneo, Sumatra, and nearby islands, such as Sulawesi.

»

» SQUIRRELS AND CHIPMUNKS

6½–10½ in
17–27 cm

GAMBIAN SUN SQUIRREL
Heliosciurus gambianus
A common species in savanna woodlands across Africa, from Senegal to Zimbabwe, this squirrel feeds mainly on the seeds of Acacia trees.

long, bushy tail

9½ in
24 cm

CAPE GROUND SQUIRREL
Xerus inauris
This coarsely haired squirrel escapes the extreme temperatures of the semideserts of South Africa by sheltering in burrows.

6–8 in
15–20 cm

GOLDEN-MANTLED GROUND SQUIRREL
Callospermophilus lateralis
Appearing like a larger version of the chipmunk, this species is a common sight in forests and mountains of the western USA.

10–12 in
25–30 cm

COLUMBIAN GROUND SQUIRREL
Urocitellus columbianus
A rather large, bushy-tailed ground squirrel, this species forms colonies in meadows and forest edges from Idaho, USA, north into western Canada.

4¾–6 in
12–15 cm

HOPI CHIPMUNK
Tamias rufus
Chipmunks from different parts of North America form separate species. This species occurs in Utah, Colorado, and adjacent parts of Arizona.

4¾–6 in
12–15 cm

short hairy tail

EASTERN CHIPMUNK
Tamias striatus
This striped, ground-living species is a common sight in forest campgrounds of the eastern USA, where it has become quite tame.

BEAVERS

There are only two species of beavers in the family Castoridae. Both are exploited for their fur. One is widespread across North America, and the other in patches throughout most of Europe. Both build dams out of stones, mud, and trees, creating habitats for other species.

BEAVER
Castor sp.
European and North American beavers are different species, but both live a similar, semiaquatic life in rivers and lakes.

glossy, brown fur

2½–4 ft
0.8–1.2 m

flat, scaly tail

GOPHERS

Members of the family Geomyidae, found in North America, live alone in shallow burrows that allow them to access roots and leaves. They carry their food in cheek pouches and store it in underground chambers.

5–9½ in
13–24 cm

BOTTA'S POCKET GOPHER
Thomomys bottae
A small burrowing creature of soft soil and grassy areas, this species digs up mounds of earth, which can damage farm machinery.

DORMICE

The Gliridae occur in wooded habitats across Europe, sub-Saharan Africa, and patchily in Central Asia, with a single species in Japan. Resembling small nocturnal squirrels, all but one are soft-furred, arboreal species. Many are threatened or are declining in numbers.

AFRICAN DORMOUSE
Graphiurus sp.
There are 14 species of African dormice. They are all similar in appearance and inhabit forested areas of sub-Saharan Africa.

bushy tail

2¾–6 in
7–15 cm

POCKET MICE AND KANGAROO RATS

Mostly common, with a few rare species, the Heteromyidae are found in varied habitats from Canada to Central America, with kangaroo rats living mainly in deserts. Pocket mice typically run on four feet, but kangaroo rats hop on two large hind feet.

MARMOT
Marmota sp.
Several species of marmots inhabit mountain grasslands and rocky areas of North America, while some occur in Eurasia. Marmots hibernate for up to nine months.

DESERT POCKET MOUSE
Chaetodipus penicillatus
This species is one of many small nocturnal rodents that inhabit the open sandy deserts of the southwest USA and northern Mexico.

MERRIAM'S KANGAROO RAT
Dipodomys merriami
Bounding away with its tail outstretched, this nocturnal inhabitant of the North American deserts looks like a miniature kangaroo.

HARRIS'S ANTELOPE SQUIRREL
Ammospermophilus harrisii
An agile inhabitant of the Sonora Desert and northern Mexico, this rodent is active in the heat of the day, but hibernates during winter.

BLACK-TAILED PRAIRIE DOG
Cynomys ludovicianus
Active during daytime, this ground squirrel lives in large groups in "towns" consisting of extensive communal burrows.

JUMPING MICE

The family Dipodidae is made up of jerboas, birch mice, and jumping mice. Their powerful hind feet and long tail enable them to bound around like miniature kangaroos.

LESSER EGYPTIAN JERBOA
Jaculus jaculus
This desert species is found across North Africa, from Senegal to Egypt, south to Somalia, and east to Iran.

MEADOW JUMPING MOUSE
Zapus hudsonius
Found in the cool grasslands of northern North America, this species also has isolated populations in the mountains of Arizona and New Mexico.

EDIBLE DORMOUSE
Glis glis
Known in Germany as "the seven-sleeper", this dormouse hibernates for over six months. It is eaten in Mediterranean countries, such as Slovenia.

VOLES, LEMMINGS, AND MUSKRATS

About 680 chubby, short-tailed rodents, including hamsters, voles, lemmings, and muskrats, make up the family Cricetidae. They are found worldwide, from western Europe to Siberia and the Pacific coast.

COMMON DORMOUSE
Muscardinus avellanarius
An excellent climber and jumper, this dormouse feeds on flowers, fruits, and insects at night, in shrubby woodland across Europe.

COMMON VOLE
Microtus arvalis
A common burrowing inhabitant of grasslands across most of northern Europe, this vole also occurs farther east and in Russia.

EURASIAN WATER VOLE
Arvicola amphibius
In Britain and parts of Europe, this vole occurs near waterside habitats, but in Russia and Iran, it lives away from water, digging extensive burrow systems.

BANK VOLE
Myodes glareolus
Active mostly at dawn and night, this typical vole inhabits scrub, woodlands, and gardens across most of western Europe and east into Russia.

NORWAY LEMMING
Lemmus lemmus
The main small mammal of the European tundra, the lemming's fluctuating population affects the breeding success of many Arctic predators.

STEPPE VOLE
Lagurus lagurus
The only species in its genus, this vole lives in the dry, grassy plains that stretch from Ukraine to western Mongolia.

MUSKRAT
Ondatra zibethicus
Originally an inhabitant of rivers, ponds, and streams in N. America, the muskrat has been introduced to Europe and is now widespread.

»

» VOLES, LEMMINGS, AND MUSKRATS

STRIPED DWARF HAMSTER
Cricetulus barabensis

By raiding crops to gather seeds and grain, this rodent can become a serious pest in farming areas. Farmers destroy its burrows while plowing.

ROBOROVSKI'S DESERT HAMSTER
Phodopus roborovskii

From the dry grasslands of central Asia, this tiny animal is popular as a pet. It breeds rapidly, up to 15 litters a year.

COMMON HAMSTER
Cricetus cricetus

This burrowing species lives alone and hibernates underground through the winter. Its burrows may contain up to 145 lb (65 kg) of stored food.

LONG-HAIRED GOLDEN HAMSTER
Mesocricetus auratus

The golden hamster has been selectively bred to create many exotic forms, such as this variety, that would not survive in the wild.

GOLDEN HAMSTER
Mesocricetus auratus

Originally from Syria, where it is now an endangered species, this hamster has become a favorite household pet in Europe and North America.

WHITE-FOOTED MOUSE
Peromyscus leucopus

A very common and adaptable creature, this mouse inhabits almost every type of land habitat in central and the eastern USA.

HISPID COTTON RAT
Sigmodon hispidus

This short-lived, surface-dwelling herbivore lives in grassland habitats in the southern USA and Mexico.

MICE, RATS, AND RELATIVES

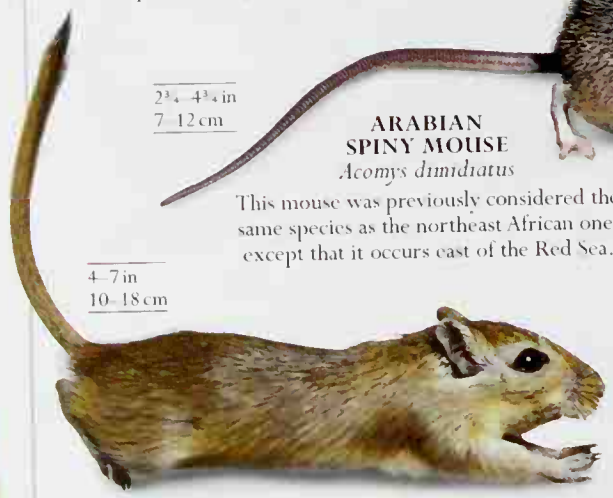
One fifth of all mammal species belong to this huge family. The Muridae are distributed almost worldwide, including the polar regions. Some species carry serious diseases, and others are significant agricultural pests. However, several are used in medical research and are commonly kept as pets.

NORTHEAST AFRICAN SPINY MOUSE
Acomys cahirinus

Like other spiny mice, this rodent has stiffened hairs on its body for protection and very thin skin, which permits easy cooling in its hot, dry habitat.

ARABIAN SPINY MOUSE
Acomys dimidiatus

This mouse was previously considered the same species as the northeast African one, except that it occurs east of the Red Sea.



SHAW'S JIRD
Meriones shawi

Common in the deserts of North Africa and the Middle East, this rodent does not hibernate, but survives the winter by storing up to 22 lb (10 kg) of food in its burrows.

MONGOLIAN JIRD
Meriones unguiculatus

In the wild, this gerbil lives in the dry steppes of central Asia, forming large social groups. Many are now kept as pets.

PALLID GERBIL
Gerbillus perpallidus

Like most small desert rodents, this gerbil has a pale body. It is widespread in North Africa and the Middle East, where its coloration provides good camouflage.

FAT-TAILED JIRD
Pachyuromys duprasi

Like many small, desert-living mammals, this species stores fat in its tail. The tail has no fur, allowing it to radiate excess body heat.

pale fur, with grayish brown markings

SLENDER CLOUD RAT
Phloeomys pallidus
The two species of cloud rat inhabit high forests of the Philippines, but are rarely seen. This species is found only in northern Luzon.

10–18 in
25–45 cm

11–19 in
28–48 cm

SOUTHERN LUZON GIANT CLOUD RAT
Phloeomys cumingi
Like the smaller northern species, this rat spends the day in hollow trees or burrows, and has one young at a time.

3½–4¾ in
9–11 cm

HOUSE MOUSE
Mus musculus
A highly adaptable species, this small, slim rodent has followed humans all around the world, even living in the Antarctic.

2¾–4 in
7–10 cm

white underparts

ALBINO DOMESTIC MOUSE
Mus musculus
The captive-bred albino house mouse has become common as a pet, and is also widely used in medical and scientific research.

2¾–4 in
7–10 cm

robust body

long whiskers on nose, eyebrows, and cheeks

grayish brown fur

8½–11½ in
21–29 cm

3½–5½ in
9–14 cm

3½–5 in
9–13 cm

YELLOW-NECKED MOUSE
Apodemus flavicollis
This nocturnal woodland species is difficult to distinguish from the wood mouse over much of its European range.

3½–4¾ in
9–11 cm

WOOD MOUSE
Apodemus sylvaticus
This is the most abundant wild mouse in Europe, living in every terrestrial habitat, even in the mountains.

small ears

HARVEST MOUSE
Micromys minutus
Europe's smallest mouse, this species lives in a variety of grassy habitats, including reed beds and cornfields.

2–3½ in
5–8 cm

6–9½ in
15–24 cm

BLACK RAT
Rattus rattus
Often called the "ship rat" because of its ability to live aboard ships, this is also the species whose fleas transmit bubonic plague.

13–14 in
30–35 cm

BROWN RAT
Rattus norvegicus
Also called the common rat, this is now a global pest, having traveled on ships and colonized even remote islands.

STRIPED GRASS MOUSE
Lemniscomys striatus
This distinctive, boldly marked species is a common inhabitant of grassy habitats across most of sub-Saharan Africa.

MALAGASY GIANT RAT
Hypogeomys antimena
The sole species of giant hopping rat, this is the largest rodent in Madagascar, found only in the sandy forests of the west coast.

BAMBOO RATS AND RELATIVES

The family Spalacidae includes blind mole rats, bamboo rats, root rats, and zokors. Big, protruding incisors characterize the blind mole rats. Adapted to an underground life, they have no external eyes and ears. The bamboo rats of eastern Asia have visible eyes.

6–10 in
15–26 cm

LESSER BAMBOO RAT
Cannomys badius
Found from Nepal to Vietnam, this single species of its genus digs deep burrows in forests, grassy areas, and sometimes gardens.

6½–14 in
17–35 cm

GREATER MOLE RAT
Spalax microphthalmus
This blind species has sensory bristles running from its snout to its eye sockets. It is native to the steppes of Ukraine and southeastern Russia.

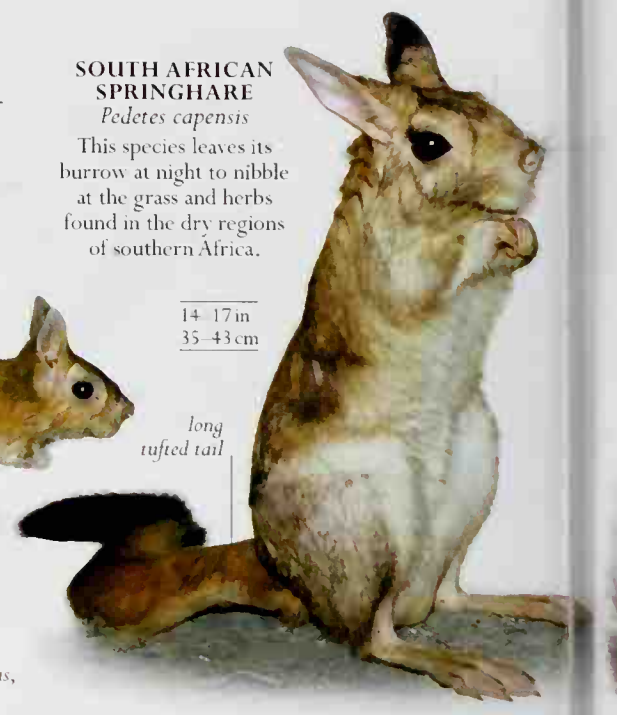
SPRINGHARES

Resembling rabbits in size and behavior, the Pedetidae differ in producing only one young at a time. They breed all year round, but living in dry, open habitats makes them vulnerable to predators.

14–17 in
35–43 cm

long tufted tail

EAST AFRICAN SPRINGHARE
Pedetes surdaster
Springhares escape their noctural predators with kangaroo-like leaps. Less common than *Pedestes capensis*, this species lives on the Serengeti plain in Africa.



SOUTH AFRICAN SPRINGHARE
Pedetes capensis
This species leaves its burrow at night to nibble at the grass and herbs found in the dry regions of southern Africa.

14–17 in
35–43 cm

AFRICAN MOLE-RATS

Living entirely underground, the Bathyergidae have only rudimentary eyes. They burrow in sand and soft soils to feed on roots, using their large, protruding front teeth as shovels. Their lips close behind the teeth to save the mouth filling with dirt.

3¼–4 in
8–10 cm

long, protruding incisor teeth

long, rounded tail

NAKED MOLE-RAT
Heterocephalus glaber
This highly social animal lives in a colony, where each individual performs different, specialized jobs to help the colony as a whole.

3½–10½ in
9–27 cm

COMMON MOLE-RAT
Cryptomys hottentotus
Found from Tanzania to South Africa, this common species lives in soft soils and farmland, where it feeds mainly on roots.

NAMAQUA DUNE MOLE-RAT
Bathyergus janetta
Native to Namibia and southwestern South Africa, this species uses its forefeet rather than its teeth to dig burrows.

7–13 in
17½–33 cm

NEW WORLD PORCUPINES

Tree-dwelling animals in American forests, the Erethizontidae have short spines, which are generally less than 4 in (10 cm) long. Most have a prehensile tail to grip branches.

26–32 in
65–80 cm

NORTH AMERICAN PORCUPINE
Erethizon dorsata
This forest dweller is found throughout North America, from Alaska to Mexico. Its spines are hidden among its shaggy fur.

12–23½ in
30–60 cm

BRAZILIAN PORCUPINE
Coendou prehensilis
This nocturnal species inhabits forested areas of South America and Trinidad. It sleeps by day and forages for leaves and shoots at dusk.

OLD WORLD PORCUPINES

Found across most of Africa and southern Asia, the 14 species of the family Hystricidae family live in burrows. They are covered with long, stiff quills that protect them against most predators. When attacked, they often rattle their quills as a reminder of how sharp and impenetrable these are.

spines are modified hair

CRESTED PORCUPINE
Hystrix cristata
23½–39 in
60–100 cm
Widespread across the northern half of Africa, except the Sahara, the crested porcupine is a [illegible] rodent.

30–39 in
75–100 cm

CAPE PORCUPINE
Hystrix africaeaustralis
Found in savanna across most of southern Africa, this species forages at night, alone or in groups, sniffing out roots and berries.

VISCACHAS AND CHINCHILLAS

All seven members of the family Chinchillidae from South America have a prominent tail and large hind feet. They normally live in social groups, inhabiting burrows or rocky outcrops. Most species are now quite rare because of their exploitation for fur and their status as pests.

CHINCHILLA
Chinchilla sp.
Widely prized for their fur, chinchillas have a fine, thick coat that insulates them against the cold in their Andean home.

9–15 in
22–38 cm

MOUNTAIN VISCACHA
Lagidium viscacia
This agile rodent has dense fur to protect it from the cold at night. It lives on steep, rocky, mountain slopes.

12–18 in
30–45 cm

DASSIE RAT

This single species in the family Petromuridae is found only in southern Africa. Its peculiar, flat skull and soft ribs are adaptations to living in crevices and under stones, and distinguish it from all other rodents.

5½–8 in
14–20 cm

DASSIE RAT
Petromus typicus
Living on dry, rocky hillsides, this rodent emerges from crevices at dawn and dusk to forage for seeds and shoots.

CANE RAT

The two species of the family Thryonomyidae have pale brown, coarse, flattened hair that blends with their surroundings in dry grass and cane thickets. Cane rats produce two small families of well-developed young per year.

14–23½ in
35–60 cm

CANE RAT
Thryonomys sp.
There are two species of African cane rats: one lives in savanna grasslands and the other in reedbeds and marshes.

PACARANA

The single species of the family Dinomyidae is a shy, bulky, slow-moving, and almost defenseless animal. It lives alone or in pairs in montane forests, where it is preyed upon by jaguars and humans.

28–32 in
70–80 cm

PACARANA
Dinomys branickii
Threatened by loss of its South American forest habitat, and hunted for food, the pacarana is now an endangered species.

GUINEA PIGS AND PATAGONIAN HARES

Including some of South America's most widespread and abundant rodents, the Caviidae occur from mountain meadows to tropical floodplains, and breed all year round. All but the mara are short-legged and dumpy animals.

8–16 in
20–40 cm

BRAZILIAN GUINEA PIG
Cavia aperea
Guinea pigs mostly live in lowland habitats, but this species is also found in the Andes, from Peru to Chile.

8–16 in
20–40 cm

ROSETTE GUINEA PIG
Cavia porcellus
Several coat variations occur in pet guinea pigs. In this one, the fur forms substantial spiky whorls over the body.

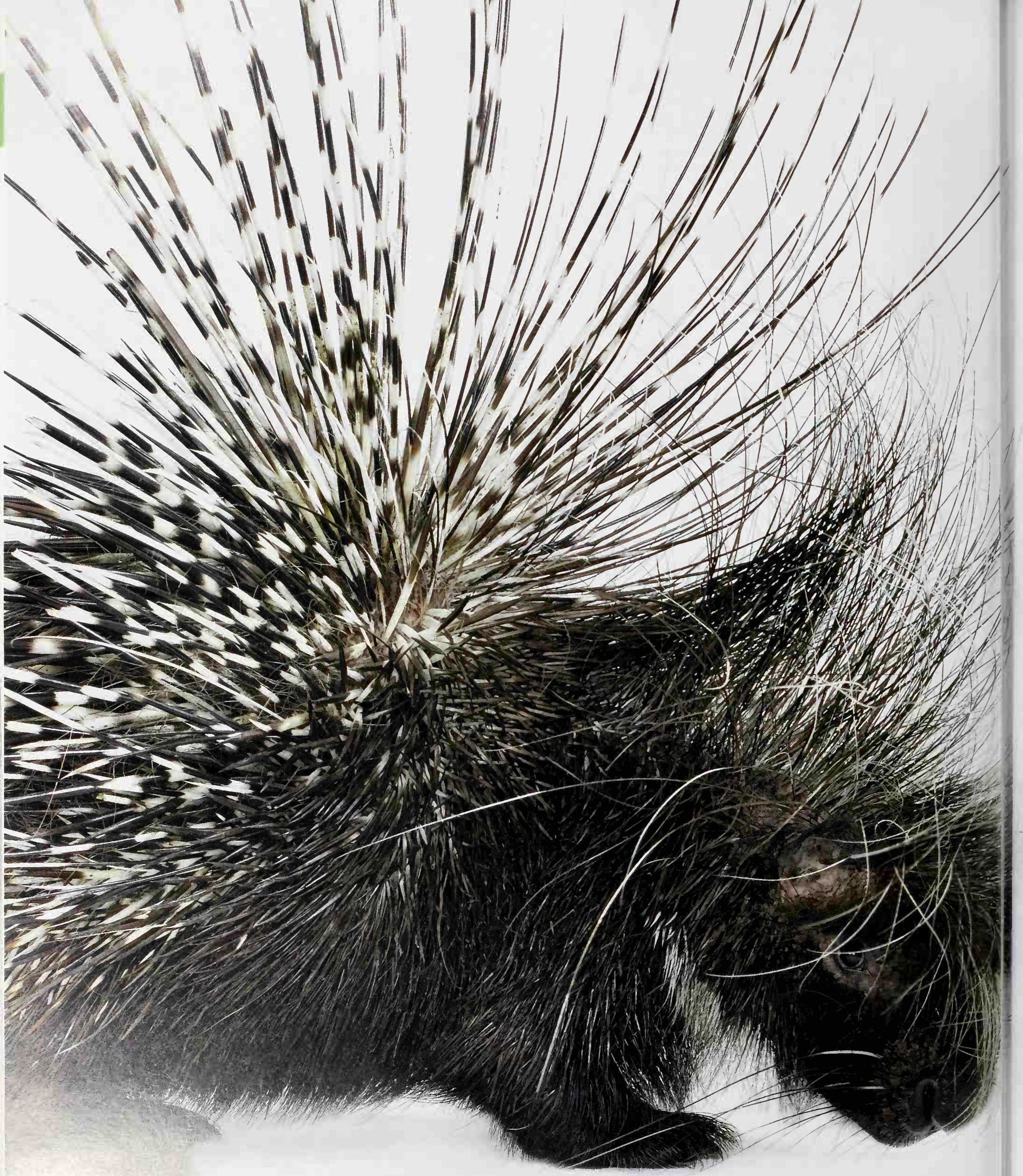
LONG HAIRED GUINEA PIG
Cavia porcellus
Often kept as a pet, in captivity this long-haired breed needs grooming to prevent its fur from becoming tangled.

8–16 in
20–40 cm

DOMESTIC GUINEA PIG
Cavia porcellus
First domesticated more than 500 years ago for food, guinea pigs have since become popular pets worldwide.

27–30 in
69–75 cm

MARA
Dolichotis sp.
Extensive shared burrow systems and communal breeding habits are among the unusual features of these long-legged rodents.



CRESTED PORCUPINE
Hystrix cristata

With its long, barbed quills raised in threat, the crested porcupine is an intimidating prospect. A predator that has had the painful experience of being spiked is unlikely ever to attempt another attack. Lions, hyenas, and even people have been known to die from infected quill injuries. Despite this impressive means of defense, the porcupine is a peaceable and rather nervous animal, easily startled, and more likely to flee danger than stand its ground. Porcupines live alone or in family groups, sharing extensive burrow systems. Crested porcupines occur throughout much of northern Africa. The species was also once widespread in southern Europe—the population found in Italy may be a relic of former times or the result of a more recent introduction, perhaps by the Romans.

SIZE 23½–39 in (60–100 cm)
HABITAT Savanna grassland, light woodland, rocky terrain
DISTRIBUTION Northern Africa as far south as Tanzania, except Sahara Desert; also Italy
DIET Mainly roots, fruits, and tubers; occasionally carrion

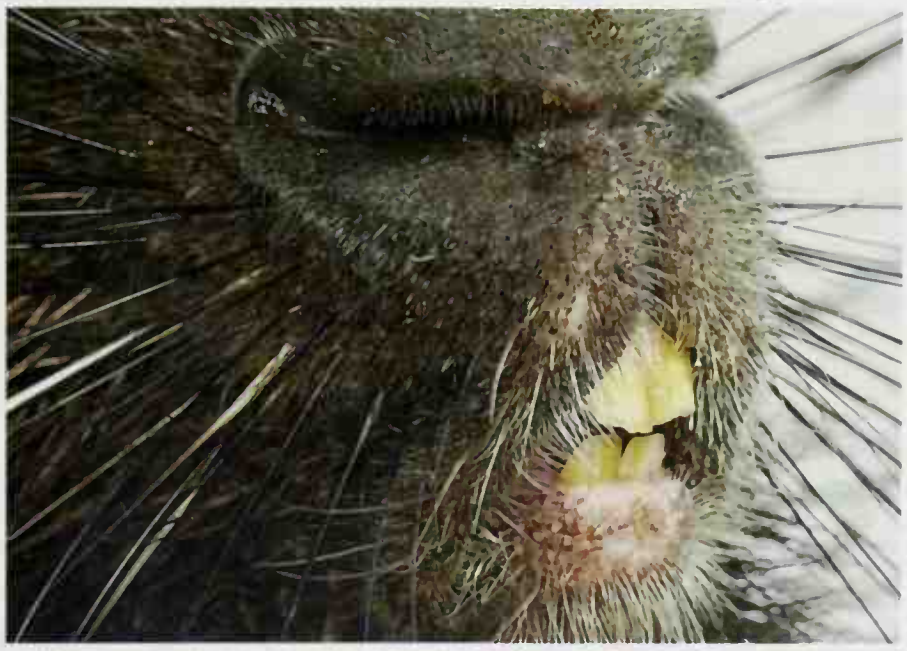
< SPIKY HAIRDO
Raising the quills creates an illusion of size. A cornered porcupine will stand tall and try to bluff its way out of trouble. If this fails, it will turn tail and charge backward, shoving its spiky rear end in the face of its attacker.

EAR >
The small ears are largely hidden in the coarse hair. The porcupine has good hearing, which it uses to avoid danger, shuffling off into the night if it hears another animal approaching.

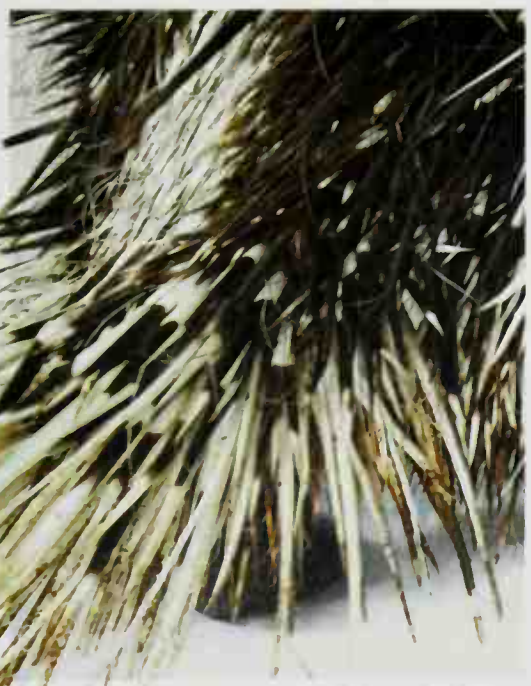
v EYE
A porcupine's eyesight is poor, but then there is often little to see in the darkness of an African night. It uses its sharp senses of hearing and smell to find its way.

v MOUTH AND TEETH
Porcupines have the specialized gnawing teeth typical of rodents, enabling them to chew tough roots and tubers. The muscles that control the jaws are immensely powerful.

QUILLS-A-QUIVER >
Porcupine quills are greatly enlarged hairs. They can be raised by larger versions of the tiny muscles that create goosebumps in our own skin.



Like its quills, the porcupine's thin coat of coarse hair can also be raised in alarm



RATTLING TAIL ^
The quills of the tail are swollen and hollow. The porcupine shakes them when alarmed and the soft rattling sound warns its enemies that this is a well-armed opponent.

< ^ FEET AND CLAWS
Porcupines walk on the flat soles of their feet, with a slightly clumsy, shambling gait. The soles are hairless and padded. They have short toes and strong claws, well suited to digging.

CAPYBARA

The subfamily Hydrochoerinae contains four species, including the largest rodent, the capybara. Capybaras have one family per year; the offspring are born at the end of the wet season, when the grass is most nutritious. They may live up to six years.

CAPYBARA
Hydrochoeris hydrochaeris
As big as a pig, this is the world's largest rodent. It lives a semiaquatic life in the swamps of South America.

3¼–4¼ ft
1–1.3 m

SPINY RATS

Mainly herbivores, some of these rodents also eat insects. Most have bristly fur, but not all. The Echimyidae are widely distributed in South America, but most are poorly known and some are extinct.

SPINY RAT
Proechimys sp.
These rodents have a spiny protective coat. This feature has evolved in parallel to the spiny mice of Africa.

6½–12 in
16–30 cm

HUTIAS

The seven extant species of the Capromyidae live in forests on different islands of the Caribbean. Six species are threatened with extinction; only the Cuban hutia is relatively secure.

12–17 in
30–43 cm

DESMAREST'S CUBAN HUTIA
Capromys pilorides
This hutia is common in Cuba. Other surviving hutia species face extinction because of a loss of their habitat and hunting.

PACAS

This family includes two species of nocturnal rodent from Central and South America. The Cuniculidae resemble small pigs as they root about on the forest floor for fruits, seeds, and roots.

23½–32 in
60–80 cm

PACA
Cuniculus paca
Mainly a forest inhabitant, this rodent lives in Central and South America, from Mexico to Paraguay.

DEGUS, ROCK RATS, AND RELATIVES

The molar teeth of these small, silky furred rats form a figure-of-eight shape when worn, giving them their Latin name. The Octodontidae are widespread in the southern part of South America.

DEGU
Octodon degus
This species is found on the western slopes of the Andes in Chile. Its tail breaks off easily if caught by a predator.

4¾–7½ in
12–19 cm

AGOUTIS

Active during the day, these long-legged, running rodents of the family Dasyproctidae are very shy. They breed all year round but have only two young at a time, which can run within an hour of birth.

RED-RUMPED AGOUTI
Dasyprocta leporina
Found in forested areas of northeastern South America and the Lesser Antilles, this species can be identified by its light orange rump.

16–24 in/41–62 cm

COYPU

The only member of the family Myocastoridae, the coypu was originally from the swamps of South America. It was introduced to Europe for the fur trade, and individuals that escaped established wild populations.

14–26 in
36–65 cm

COYPU
Myocastor coypus
This animal has distinctively shaggy fur and huge orange front teeth. It also has webbed hind feet for swimming and a thick, scaly tail.

16–24 in
41–62 cm

CENTRAL AMERICAN AGOUTI
Dasyprocta punctata
With a range that extends from Mexico south to Argentina, this agouti mainly feeds on fruits, but may also eat crabs. Pairs are thought to stay together for life.

16½–24 in
42–62 cm

AZARA'S AGOUTI
Dasyprocta azarae
An inhabitant of the forests of southern Brazil, Paraguay, and northern Argentina, this agouti barks when alarmed. It eats a variety of seeds and fruits.

TREE SHREWS

These small mammals look and behave like squirrels. They are active in the daytime and spend much of their time foraging for food on the ground.

Tree shrews are native to the tropical rain forests of Southeast Asia. They are unrelated to the true shrews and have their own order, Scandentia. Sharp claws on all their fingers and toes enable tree shrews to climb trees rapidly but, despite their name, most of them are only partly arboreal. Their mixed diet includes insects, worms, fruits, and sometimes small mammals, reptiles, and birds.

Some tree shrews are solitary, while others live in pairs or groups. They are rapid breeders, raising their young in nests in tree crevices or on branches. The female pays her brood little attention, making only the occasional short visit to suckle them.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	SCANDENTIA
FAMILIES	2
SPECIES	20

PEN-TAILED TREE SHREW

The family Ptilocercidae has only one member, the Southeast Asian pen-tailed tree shrew. The species is named for its long, feathery tail, which resembles a quill pen. This aids balance when climbing.

4–5½in
10–14cm

PEN-TAILED TREE SHREW
Ptilocercus lowii
This species has a rather spindly tail with a brushy tip, unlike most other tree shrews, which have a thick, bushy tail.

TREE SHREWS

Members of the family Tupaiidae have long snouts, which are used to locate insects and other invertebrates as well as fruits and leaves. Tree shrews also have sharp claws on all their fingers and toes, helping them climb trees rapidly.

GREATER TREE SHREW
Tupaia tana
Tree shrews are nocturnal inhabitants of Southeast Asian forests. This species is found in Borneo and Sumatra and on nearby islands.

COLUGOS

The two species that form the order Dermoptera are gliding, rather than flying, mammals. They are found in the rain forests of Southeast Asia.

The colugos are distinguished by a furry membrane that stretches from the neck to the tips of the fingers and tail. When the limbs are splayed this membrane spreads out, allowing the lemur to maneuver in the air as it glides from tree to tree. The distance covered in a glide may be more than 330ft (100m). Colugos live in the canopy, hanging upside down from branches or sheltering in cracks or hollow trees by day and emerging at night to feed on fruits and leaves. They are almost unable to move on the ground.

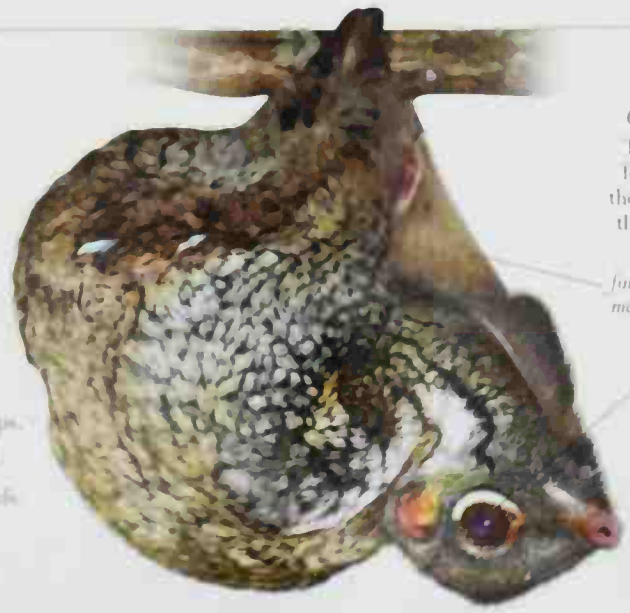
The teeth of colugos are unlike those of any other mammal. In the lower jaw, the teeth are arranged like combs and are believed to be used for grooming as well as for feeding.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	DERMOPTERA
FAMILIES	1
SPECIES	2

FLYING LEMURS

The only two members of the Cynocephalidae have a furry membrane stretching from the neck to the tips of fingers and tail, which helps them glide from tree to tree. They also have peculiar comblike lower teeth, used to strain food such as fruits and flowers.

COLUGO
Cynocephalus variegatus
This lemur lives alone or in small groups, inhabiting tree holes or resting high on treetops in the tropical forests of Southeast Asia and the Indonesian islands.



PHILIPPINE FLYING LEMUR
Cynocephalus volans
The only local species found in the forests of the southern Philippines, this lemur is nocturnal.

PRIMATES

The order to which humans belong, primates have a large brain relative to their size and forward-facing eyes which give them 3-D vision.

With the exception of a few species, including humans, primates are restricted to tropical and subtropical regions of the Americas, Africa, and Asia. They range in size from a mouse lemur, weighing 1 oz (30 g), to a gorilla weighing up to 440 lb (200 kg).

Primates rely more on vision than on smell. Many are arboreal and have characteristics such as stereoscopic vision, allowing good judgement of distance for jumping between trees; opposable thumbs and prehensile tails for grasping branches; long legs for leaping; and long arms for swinging. Some primates have specialized diets, but many other species are omnivorous.

MAJOR GROUPS

Primates are divided into two suborders. The Strepsirrhini includes the mostly nocturnal lemurs, lorises, galagos, and their relatives. These species have a better developed sense of smell than other primates. The Haplorrhini includes the New and Old World monkeys and the apes, many of which are diurnal, and so more reliant on vision than the Strepsirrhini.

SOCIAL PATTERNS

Most primates are highly social, living in small family groups, single-male harems, or large mixed-sex troops. Many species are characterized by high levels of male competition for females. Sexual selection favouring the largest or most dominant males has led to sexual dimorphism—differences between males and females in body size or features such as canine teeth. The different sexes may also be differently colored, a form of dimorphism known as sexual dichromatism.

Most New World monkeys are monogamous, with both parents sharing responsibility for raising their young. Old World monkeys tend to live in groups dominated by related females, and the males take little or no part in parental duties. Primates are generally slow to mature fully and slow to reproduce, but they are relatively long-lived. The larger apes have a potential lifespan of up to 45 years in the wild, and longer in captivity.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	PRIMATES
FAMILIES	13
SPECIES	About 250

DEBATE

PRIMATE HOTSPOTS

Today scientists list more species of primates than a decade ago—most the result of subspecies (geographical variants) being recognized as new species. In the Amazon basin populations of monkeys separated by rivers and mountain ranges can differ in subtle ways—such as in the structure of their chromosomes. Some scientists believe that these monkeys diverged when their forest habitats became isolated due to geological activity many thousands of years ago. Such forests may contain many species isolated in this way and are a particular focus of conservation groups aiming to protect biodiversity.

BUSHBABIES AND GALAGOS

Native to sub-Saharan Africa, the members of the family Galagidae inhabit a wide range of woodland and forest habitats, including scrub and wooded savanna. They have longer hind legs than forelegs, which help them take large leaps between trees in forests. These primates often wash their hands and feet with urine, which may help improve their grip and leave scent trails. All are nocturnal.

SILVERY GREATER GALAGO
Otolemur monteiri
This species has the same range as the brown greater galago but prefers denser vegetation. Despite its name, melanistic (black) forms are common.

BROWN GREATER GALAGO
Otolemur crassicaudatus
One of the largest galagos, this primate lives in a variety of forests in southern Africa. This omnivore uses its comblike teeth to scrape gum from trees.

LORISES AND POTTOS

These small, nocturnal omnivores have short tails, and their forelimbs and hind limbs are of equal length. The Lorisidae have opposable thumbs for grasping branches and they move much more slowly and sedately through the trees than the galagos—climbing rather than leaping.

10–15 in
26–38 cm

SLOW LORIS
Nycticebus coucang
As its name suggests, this loris moves slowly and deliberately through the trees. It inhabits tropical forest in Southeast Asia.

6–10 in
15–25 cm

PYGMY SLOW LORIS
Nycticebus pygmaeus
This species inhabits thick tropical rainforest and bamboo forest in Laos, Cambodia, Vietnam, and southern China.

RED SLENDER LORIS
Loris tardigradus
Native to Sri Lanka, this slender primate moves carefully through the forest canopy on its long limbs.

9–12 in
22–31 cm

12–16 in
30–40 cm

POTTO
Perodicticus potto
A shy species, this primate lives in thick rain forest across equatorial Africa. A bony shield at the nape of its neck protects it against predators.

GOLDEN ANGWANTIBO
Arctocebus aureus
Also called the golden potto, this species inhabits the understory of moist lowland forest in equatorial West and central Africa.

SENEGAL BUSHBABY
Galago senegalensis
Widespread across central Africa and parts of East Africa, the lesser, or Senegal, bushbaby inhabits arid savanna woodland.

4¾–8 in
12–20 cm

5½–6½ in
14–17 cm

DEMIDOFF'S BUSHBABY
Galago demidoff
Also called the dwarf bushbaby, this small primate uses its long hind legs to jump through rain forest canopies of West and central Africa.

4¼–5 in
10.5–12.4 cm

MOHOLI BUSHBABY
Galago moholi
This small, shy galago lives in small groups in southern Africa. Lithe and agile, it leaps through woodland, where it eats insects and tree gum.

TARSIERS

The small Tarsiidae are named for their greatly elongated anklebone or tarsus. These arboreal species have long limb bones, elongated fingers, and a long, thin tail. Their round heads have very large eyes, which help them see at night while hunting for insects.

3¼–6¼ in
8.5–16.5 cm

HORSFIELD'S TARSIER
Tarsius bancanus
Adapted for clinging and leaping between trees, this species, also called the western tarsier, lives in the tropical rain forests of Sumatra and Borneo.

3¼–6½ in
8.5–16 cm

PHILIPPINE TARSIER
Tarsius syrichta
Endemic to a variety of rain forest and scrub in the Philippines, this tarsier possesses the largest eyes relative to its body size among all mammals.

LEMURS

Found in forests across Madagascar, the family Lemuridae is made up of the most typical lemurs: mainly arboreal and quadrupedal. Most are cathemeral, meaning they are active during the day and night. In several species, males and females are differently colored.

16–16½ in
40–42 cm

GREATER BAMBOO LEMUR
Prolemur simus
One of the rarest lemurs, this species lives in southeastern Madagascar, where it feeds almost exclusively on giant bamboo.

15½–18 in
39–46 cm

RING-TAILED LEMUR
Lemur catta
Living in groups of up to 25 individuals, this lemur often spends time on the ground. Its diet consists of fruits, vegetation, sap, and bark.

20–23½ in
51–60 cm

BLACK AND WHITE RUFFED LEMUR
Varecia variegata
The largest lemur, this species eats a high proportion of fruit. Unusual for lemurs, it makes a leafy nest for its young.

15–16 in
38–40 cm

thick woolly fur

BANDRO
Hapalemur alaotrensis
Also called the Alaotran bamboo lemur, this critically endangered species lives only in papyrus marsh and reedbeds around Lake Alaotra, Madagascar's largest lake.

14–16½ in
35–42 cm

RED-BELLIED LEMUR
Eulemur rubriventer
A monogamous species, this lemur lives in small groups that consist of a mated pair and their dependent young.

RED-COLLARED LEMUR
Eulemur collaris
This lemur has a scent gland on its wrist, with which it perfumes its long, furry tail for use in communication.

15–20 in
38–50 cm

tail is as long as body

15½–16½ in
39–42 cm

WHITE-HEADED LEMUR
Eulemur albifrons
Only the male of this species has distinctive white fur around its black face; the female has a gray face.

12½–14½ in
32–37 cm

red cheek patch in male

♂

BLACK LEMUR
Eulemur macaco
This is a sexually dichromatic species: the colors of males and females vary. Only the male is black; the female is gray-brown with white ear tufts.

MONGOOSE LEMUR
Eulemur mongoz
Primarily nocturnal during the dry season, the mongoose lemur becomes more diurnal at the start of the wet season.

grasping hands

15–18 in
38–45 cm

♀

DWARF LEMURS AND MOUSE LEMURS

Among the smallest of all primates, the members of the family Cheirogaleidae have short limbs and large eyes. All are nocturnal, arboreal inhabitants of forests in Madagascar, and become torpid to survive the dry season.

9–12 in
22–30 cm

PALE FORK-MARKED LEMUR
Phaner pallescens
Adapted to eat tree gum, this lemur has a long tongue and large premolars for chiseling bark

4½–6 in
12–15 cm

GRAY MOUSE LEMUR
Microcebus murinus
An omnivore, this lemur's diet includes insects, flowers, and fruits. The female carries the infant in her mouth for the first few weeks.

4–8 in
10–20 cm

EASTERN RUFOUS MOUSE LEMUR
Microcebus rufus
Inhabiting a range of forest habitats, this omnivorous species consumes a variety of fruits, insects, and gum.

6½–10 in
17–26 cm

short limbs

GREATER DWARF LEMUR
Cheirogaleus major
This solitary lemur feeds mainly on fruits and nectar. It stores fat in its tail during the wet season.

SPORTIVE LEMURS

The family Lepilemuridae consists of the sportive lemurs of Madagascar. These medium-sized lemurs have prominent muzzles and large eyes, and are strictly arboreal and nocturnal. Their low-energy, leafy diet means that they are among the least active of all primates.

9–10 in
22–26 cm

WHITE-FOOTED SPORTIVE LEMUR
Lepilemur leucopus
Grayish above and white below, this lemur spends lengths of time perched vertically on tree trunks, in between bouts of foraging for food.

10 in
26 cm

BLACK-STRIPED SPORTIVE LEMUR
Lepilemur dorsalis
This species lives in moist forest in northwestern Madagascar and nearby islands. It has a blunt muzzle and small ears.

AYE-AYE

There is only one species in the Daubentoniidae—the aye-aye of Madagascar. This nocturnal primate has large, bare ears; a shaggy coat; very long fingers; and continually growing incisor teeth.

12–16 in
30–40 cm

AYE-AYE
Daubentonia madagascariensis
The aye-aye uses its elongated middle finger for locating and extracting insect larvae from dead wood.

SIFAKAS AND RELATIVES

The largest lemurs—the indri and sifakas—and the smaller avahis or woolly lemurs form the Indriidae of Madagascar. All members have long, powerful limbs for leaping between trees, and, with the exception of the indri, a long tail.

face mostly bare, with white fur along muzzle

16½–20 in
42–50 cm

long hind limbs

COQUEREL'S SIFAKA
Propithecus coquereli
Like other sifakas, this primate crosses open ground by skipping on its hind legs, using its forearms for balance.

16½–20 in
42–52 cm

MILNE-EDWARD'S SIFAKA
Propithecus edwardi
Occurring in small family groups in southeastern Madagascar, this sifaka has a large opposable thumb for clinging to tree trunks.

16–20 in
40–50 cm

VERREAUX'S SIFAKA
Propithecus verreauxi
Found in southwestern Madagascar, this sifaka is capable of leaping through cactuslike vegetation on its long legs without being injured.

23–28 in
60–72 cm

INDRI
Indri indri
The largest member of the lemur group, this is the only species to have a short, vestigial tail.

HOWLER, SPIDER, AND WOOLLY MONKEYS

The howler, spider, and woolly monkeys of the Atelidae are the largest New World monkeys. All have a prehensile tail that is used as a fifth limb when moving through the trees. Spider monkeys have longer limbs than the other members of the family.

20–28 in
50–71 cm

GUATEMALAN HOWLER MONKEY
Alouatta pigra
Found in the Yucatan Peninsula of Mexico, Belize, and Guatemala, this species forms groups of up to 11 individuals.

20–26 in
50–65 cm

BLACK HOWLER
Alouatta caraya
This species lives in central South American rain forests. Only the males are black; females are a buff-golden color.

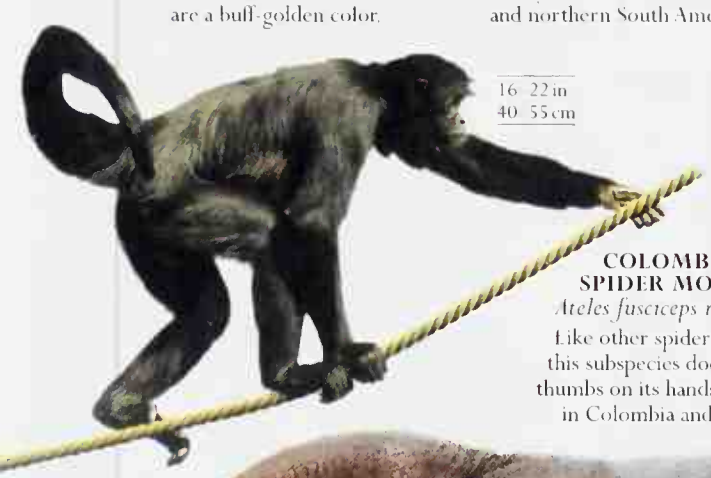
19–27 in
48–68 cm

MANTLED HOWLER MONKEY
Alouatta palliata
Named after the "mantle" of long guard hair on its flanks, this howler monkey lives in Central America and northern South America.

19–25 in
48–63 cm

large larynx for howling

VENEZUELAN RED HOWLER MONKEY
Alouatta seniculus
This howler monkey has an enlarged hyoid bone in the neck that allows it to make calls that can be heard several miles away.



16–22 in
40–55 cm

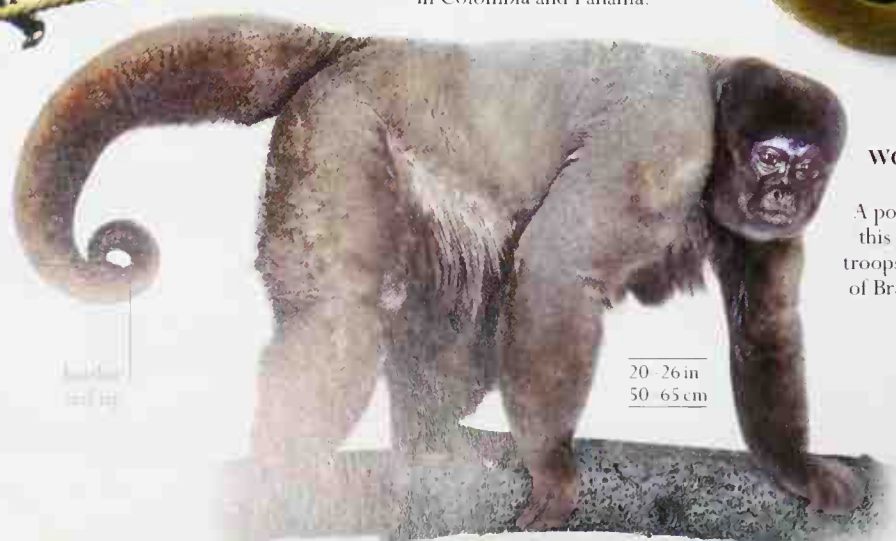
COLOMBIAN SPIDER MONKEY
Ateles fusciceps rufiventris
Like other spider monkeys, this subspecies does not have thumbs on its hands. It is found in Colombia and Panama.

12–25 in
31–63 cm

GEOFFROY'S SPIDER MONKEY
Ateles geoffroyi
Active during the day, this fruit-eating species lives in relatively large groups of up to 35 individuals in forests throughout Central America.

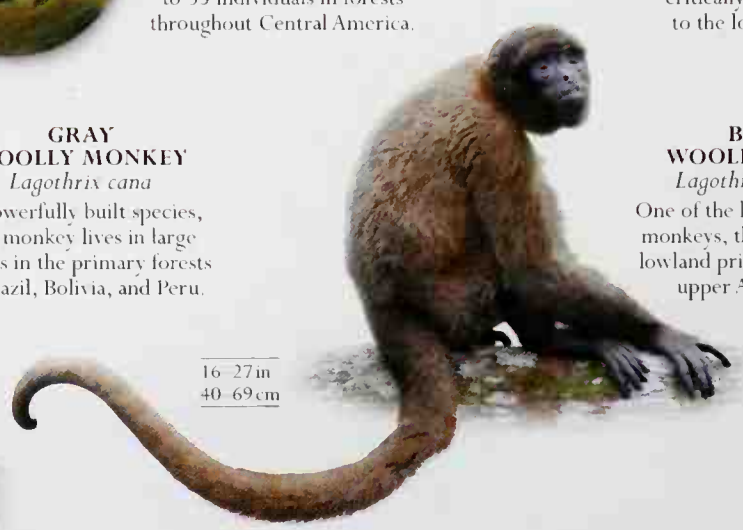
18–31 in
46–78 cm

SOUTHERN MURIQUI
Brachyteles arachnoides
Also known as the woolly spider monkey, this species, found in Brazilian forests, is critically endangered due to the loss of its habitat.



20–26 in
50–65 cm

GRAY WOOLLY MONKEY
Lagothrix cana
A powerfully built species, this monkey lives in large troops in the primary forests of Brazil, Bolivia, and Peru.



16–27 in
40–69 cm

BROWN WOOLLY MONKEY
Lagothrix lagotricha
One of the largest New World monkeys, this species lives in lowland primary forest in the upper Amazon basin.

NIGHT MONKEYS

Also called owl monkeys, the members of the Aotidae are the only nocturnal monkeys in the New World. They are small, with large eyes set in flat, round faces with dense woolly fur. They have a well-developed sense of smell.

9½–16½ in
24–42 cm

BLACK-HEADED NIGHT MONKEY
Aotus nigriceps
This monogamous species inhabits the central and upper Amazon basin in primary and secondary forests of Brazil, Bolivia, and Peru.

9½–19 in
24–48 cm

NORTHERN NIGHT MONKEY
Aotus trivirgatus
Also called the three-striped monkey, this species is most active on moonlit nights. It lives in forests in Venezuela and northern Brazil.

TITI, SAKI, AND UAKARI MONKEYS

This family contains a range of small- to medium-sized monkeys. The Pitheciidae are diurnal, arboreal, and social. All share a common dental makeup, including large, splayed canine teeth that help them deal with tough seeds and fruits.

15–19 in
38–48 cm

BLACK-BEARDED SAKI
Chiropotes satanas
This species is known from South Amazonia. The males possess a beard and large swellings on their foreheads.

black hair tipped with white

RIO TAPAJÓS SAKI
Pithecia irrorata
Also called the bald-faced saki, this species lives in western Brazil, northern Bolivia, and eastern Peru. Its diet is predominantly seeds.

12–28 in
30–70 cm

15–16½ in
38–42 cm

WHITE-FACED SAKI
Pithecia pithecia
Male white-faced or Guianan sakis are black with pale fur around the face, whereas females are gray-brown.

14½–19 in
37–48 cm

MONK SAKI
Pithecia monachus
A shy primate, this species lives in the high canopy of forests in northwest Brazil, Peru, Colombia, and Ecuador.

12–16½ in
31–42 cm

BLACK-FRONTED TITI
Callicebus nigrifrons
A fruit-eater, this titi is an inhabitant of Atlantic coastal forest around São Paulo in southeastern Brazil.

9–14 in
23–36 cm

COLLARED TITI MONKEY
Callicebus torquatus
Also known as the yellow-handed titi, this species prefers unflooded forests on sandy soils in Brazil. It feeds mostly on fruits and seeds.

10½–17 in
27–43 cm

RED-BELLIED TITI
Callicebus moloch
A strongly monogamous species, this titi maintains family territories. It lives in the low canopy of forests in central Brazil.

12–20 in
30–50 cm

BLACK-HEADED UAKARI
Cacajao melanocephalus
A highly social species, this uakari lives in groups of 30 or more individuals in the upper Amazon basin.

hairless, red face

long, shaggy coat

14–23½ in
36–57 cm

RED BALD-HEADED UAKARI
Cacajao calvus rubicundus
Several subspecies of the bald-headed uakari inhabit seasonally flooded forests of the Amazon basin. The red faces of these monkeys are thought to signal their health.

MARMOSETS, SQUIRREL MONKEYS, AND RELATIVES

The Cebidae consists of relatively small social monkeys, which inhabit a variety of forests throughout tropical and subtropical Central and South America. They are all diurnal and arboreal and have forward-facing eyes and short muzzles. All except the capuchins have long, nonprehensile tails. Marmosets and tamarins have claws instead of nails, and lack the third molar.

8½–12 in
21–31 cm

GOELDI'S MONKEY
Callimico goeldii
Inhabiting dense forest undergrowth, such as that of bamboo forest in the upper Amazon, this monkey makes forays into the tree canopy for fruits.

8–9 in
20–23 cm

SILVERY MARMOSET
Callithrix argentata
A specialized gum-eater (gumivore), this marmoset has huge ears, narrow jaws, and short canine teeth for cutting into tree bark.

4¾–6 in
12–15 cm

COMMON MARMOSET
Callithrix jacchus
The female of this species usually mates with two males, both of whom assist with parental care of the usually twin offspring.

long, curved claws

8 in
20 cm

GEOFFROY'S MARMOSET
Callithrix geoffroyi
Also called the white-headed marmoset, this species uses scent-marks to deter others from using the holes it makes in tree bark to extract gum.

9–11 in
23–28 cm

BLACK TUFTED-EAR MARMOSET
Callithrix penicillata
A monogamous species, this primate is diurnal and lives high in the rain forest canopy, where it feeds on tree sap.

4¾–6 in
12–15 cm

PYGMY MARMOSET
Callithrix pygmaea
The smallest monkey in the world, this species eats tree gum in seasonally flooded forests of the upper Amazon basin.

fine, yellow hair on back

9–10 in
23–26 cm

white mustache

EMPEROR TAMARIN
Saguinus imperator
Distinguished by its long, white mustache, this tamarin lives in the tropical forests in Peru, Brazil, and Bolivia.

9–12 in
23–30 cm

WHITE-LIPPED TAMARIN
Saguinus labiatus
The dominant female of this species releases chemical signals, called pheromones, that suppress reproduction in other female members of the group.

8½–11 in
21–28 cm

BARE-FACED TAMARIN
Saguinus bicolor
Also called the pied tamarin, this tree-dwelling primate lives in lowland forest in the central Amazon region near Manaus, Brazil.

8–10 in
20–25 cm

COTTON-TOP TAMARIN
Saguinus oedipus
Inhabiting a very restricted range in northwest Colombia and Panama, this species feeds mainly on insects and fruits.

GOLDEN-HANDED TAMARIN
Saguinus midas
Found in northeast South America, this tamarin has brightly colored hands and feet, with claws on all digits except the big toe, which has a nail.

8–10 in
20–27 cm

SADDLE-BACK TAMARIN
Saguinus fuscicollis
This tamarin lives in secondary forest and forest edges in the upper Amazon basin, foraging for insects, fruits, nectar, and tree sap and gum.

banded tail

8½–11 in
21–28 cm

8–10 in
20–25 cm

GOLDEN LION TAMARIN
Leontopithecus rosalia
Among the most endangered monkeys in the world, this species is found only in the Atlantic coastal forest of southeast Brazil.

8–14 in
20–34 cm

GOLDEN-HEADED LION TAMARIN
Leontopithecus chrysomelas
Restricted to the Atlantic forest of southern Bahia in northeast Brazil, this primate raises its mane to look bigger when in danger.

naked face

14½–18 in
37–46 cm

prehensile tail

WEEPER CAPUCHIN
Cebus olivaceus
Native to north-central South America, this capuchin often uses its prehensile tail to support its body while feeding with its hands.

12–22½ in
31–57 cm

WHITE-HEADED CAPUCHIN
Cebus capucinus
The only capuchin found in Central America, the range of this primate extends from Honduras to the coasts of Colombia and Ecuador.

LARGE-HEADED CAPUCHIN
Cebus apella macrocephalus
Capable of using tools to open hard fruits, this primate lives in the forests of western South America.

13–22½ in
33–57 cm

10½–14½ in
27–37 cm

bright yellow limbs

long tail with a black tip

10½–17½ in
27–42 cm

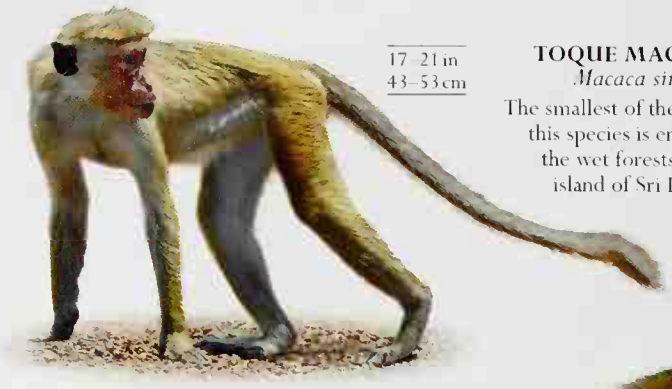
BLACK-CAPPED SQUIRREL MONKEY
Saimiri boliviensis
Males of this species become fatter around the neck and shoulders during the breeding season, when they compete for mates.

COMMON SQUIRREL MONKEY
Saimiri sciureus
A gregarious species, this monkey lives in large groups in a wide variety of forests in northern South America.

nails on digits

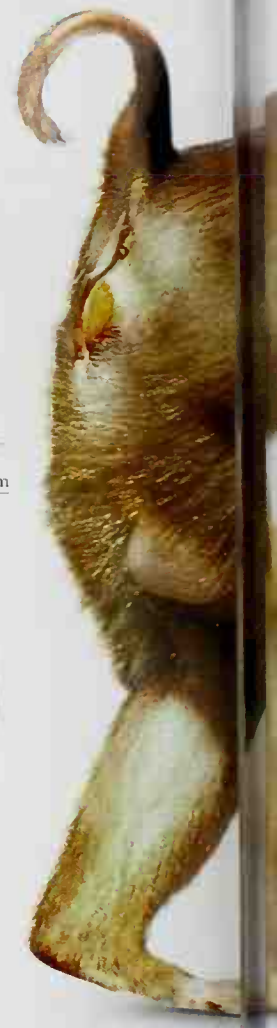
OLD WORLD MONKEYS

Widely distributed across Africa and Asia, the Cercopithecidae have closely spaced, downward-facing nostrils (catarrhine) and flattened nails. Most are diurnal and arboreal; however, baboons are mainly terrestrial. Guenons, baboons, and macaques are omnivorous, with strong jaws, cheek pouches, and a simple stomach. Colobus and leaf monkeys are leaf-eaters (folivorous) with complex stomachs, and they lack cheek pouches.



17–21 in
43–53 cm

TOQUE MACAQUE
Macaca sinica
The smallest of the macaques, this species is endemic to the wet forests on the island of Sri Lanka.

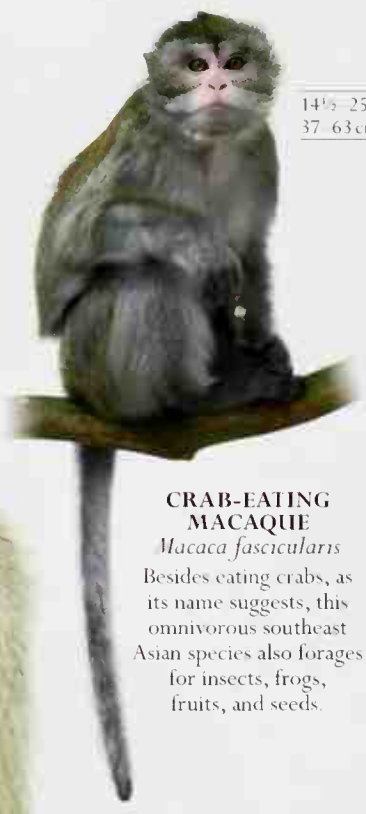


20½–22½ in
52–57 cm

CELEBES CRESTED MACAQUE
Macaca nigra
Endemic to Indonesia's Sulawesi Island, this monkey has bare, pink swellings on its rump. These become particularly swollen in females that are ready to mate.

18–28 in
45–70 cm

BARBARY MACAQUE
Macaca sylvanus
The only macaque outside Asia, the barbary macaque lives in the high cedar and oak forests of Algeria and Morocco.



14½–25 in
37–63 cm

CRAB-EATING MACAQUE
Macaca fascicularis
Besides eating crabs, as its name suggests, this omnivorous southeast Asian species also forages for insects, frogs, fruits, and seeds.

16–24 in
40–61 cm

LION-TAILED MACAQUE
Macaca silenus
Endemic to the Western Ghats, mountains in southwest India, this arboreal macaque lives mainly in wet, monsoon forests.

RHESUS MACAQUE
Macaca mulatta
This macaque lives in dry, open areas from western Afghanistan through India to northern Thailand and China. Adults swim distances of up to ½ mile (0.8 km) between islands.

19½–28 in
49–70 cm

STUMP-TAILED MACAQUE
Macaca arctoides
Both arboreal and terrestrial, this species is found in tropical and subtropical wet forests in southeastAsia.

18½–23½in
47–60cm

forearms of similar length to hind legs

SOUTHERN PIG-TAILED MACAQUE
Macaca nemestrina
This monkey inhabits humid areas, including rain forest and swamps in southeast Asia. Its diet consists mainly of fruits.

14–23½in
35–60cm

BONNET MACAQUE
Macaca radiata
Often found close to human habitation, this resident of southern India is omnivorous and may rely on humans for food.

thick fur

18½–24½in
47–60cm

JAPANESE MACAQUE
Macaca fuscata
Inhabiting the most northerly range of any nonhuman primate, the Japanese macaque uses hot springs to keep warm in winter.

opposable thumbs

17½–28in
44–70cm

WHITE-THROATED MONKEY
Cercopithecus albogularis
Also called the Sykes' monkey, this tree-dwelling omnivore is distributed in eastern and southeastern Africa, including Zanzibar and the Mafia Islands.

16–19in
41–48cm

RED-TAILED MONKEY
Cercopithecus ascanius
An arboreal species of moist forest habitats in Central Africa, the red-tailed monkey has large cheek pouches, in which it stores fruits.

18–22in
46–56cm

L'HOEST'S MONKEY
Cercopithecus lhoesti
Also known as the mountain monkey, this arboreal guenon lives in moist primary forests in the highlands of central Africa.

16–22in
40–55cm

DIANA MONKEY
Cercopithecus diana
An inhabitant of the high canopy of primary forests in West Africa, the Diana monkey rarely descends to the ground.

long, furry tail

16–25in
40–64cm

DE BRAZZA'S MONKEY
Cercopithecus neglectus
This is a semiterrestrial species of central African swamp forests. Males are larger than females and have a distinctive blue scrotum.

19½–26in
49–66cm

12½–22in
32–56cm

BLUE MONKEY
Cercopithecus mitis
Social groups of this African native number up to 40 individuals and consist of a dominant alpha male, several females, and their offspring.

MONA MONKEY
Cercopithecus mona
A tree-dwelling species, this monkey inhabits rain forests and mangrove forests from Ghana to Cameroon.

17½–25in
44–63cm

TANA RIVER MANGABEY
Cercocebus galeritus
Named after the Tana River in Kenya, where it is endemic, this terrestrial mangabey has large incisors for opening hard seeds.

ANGOLAN TALAPOIN
Miopithecus talapoin
The smallest of the Old World monkeys, the arboreal talapoin lives in wet and swampy forests in western and central Africa.

12½–18in
32–45cm

»

16–26 in
40–66 cm

GRIVET
Chlorocebus aethiops
A semiterrestrial species, the grivet lives in northeastern Africa. It is characterized by a green tinge on its upper face.

14–26 in
35–66 cm

VERVET MONKEY
Chlorocebus pygerythrus
An inhabitant of savanna and open woodland, this monkey is distributed from Ethiopia through East Africa to South Africa.

60–88 in
23½–35 in

PATAS MONKEY
Erythrocebus patas
The long limbs and short digits of this primate make it well adapted for running. It is found from West to East Africa.

15–35 in
38–89 cm

BLACK-CRESTED MANGABEY
Lophocebus aterrimus
An arboreal species that prefers rain forest, this mangabey is found in the Democratic Republic of Congo.

speckled olive-gray fur

blue flanges on either side of the nose

25–32 in
63–81 cm

MANDRILL
Mandrillus sphinx
Found in rain forest in western central Africa, this species has distinctive facial markings that are duller in females and juveniles than in males.

24–30 in
61–77 cm

DRILL
Mandrillus leucophaeus
A large terrestrial monkey of lowland mature rain forest, the drill is found only in Cameroon, Nigeria, and the Republic of Equatorial Guinea.

baboon tail typically appears broken

olive-gray body

20–43 in
51–114 cm

20–43 in
50–114 cm

CHACMA BABOON
Papio ursinus
One of the largest baboons, this species inhabits woodland, savanna, steppe, semidesert, and montane habitats across southern Africa.

YELLOW BABOON
Papio cynocephalus
An opportunistic baboon, this omnivore's diet includes seedpods, roots, insects, and other monkeys. It lives in southern and eastern Africa.

red-brown face

24–30 in
61–76 cm

HAMADRYAS BABOON
Papio hamadryas
This species is found in East and central Africa, particularly Ethiopia. The male has a long silver-gray shoulder cape.

24–30 in
61–76 cm

GUINEA BABOON
Papio papio
One of the smallest baboons, this species also has one of the smallest ranges, confined to western equatorial Africa.

19–34 in
48–86 cm

muscular limbs help it run fast

OLIVE BABOON
Papio anubis
This species forms troops of up to 100 baboons in the savanna and grassland steppe of central sub-Saharan Africa.

20–29 in
50–74 cm

GELADA
Theropithecus gelada
A grassland grazer from the highlands of Ethiopia, this primate has a distinctive bare patch of skin on its chest.

18½–31 in
47–78 cm

GOLDEN SNUB-NOSED MONKEY
Rhinopithecus roxellana
This monkey has thick fur, which helps it survive in high montane forests in west and central China.

21½–30 in
54–76 cm

PROBOSCIS MONKEY
Nasalis larvatus
A competent swimmer, this monkey inhabits mangrove and lowland riverine rain forest in Borneo. It is named for the male's large nose.

18–28 in
45–72 cm

mantle of white hair

white "cloak" over back

18½–27 in
47–68 cm

ANGOLA COLOBUS
Colobus angolensis
A predominantly arboreal species, this monkey inhabits a variety of forest habitats in Angola, Congo, and other neighboring countries.

GUEREZA
Colobus guereza
Also called the eastern black-and-white colobus, this species is widespread in the moist tropical forests of central and East Africa.

16–31 in
41–78 cm

NORTHERN PLAINS GREY LANGUR
Semnopithecus entellus
Also called the Hanuman langur, this gray monkey is found in southern Asia, including India and Pakistan.

long tail with a white, bushy tip

bright orange coloration

24 in
61 cm

TUFTED GREY LANGUR
Semnopithecus priam
Found in southeast India and Sri Lanka, this langur lives in many different habitats. Its diet consists mainly of tree foliage.

17–26 in
43–65 cm

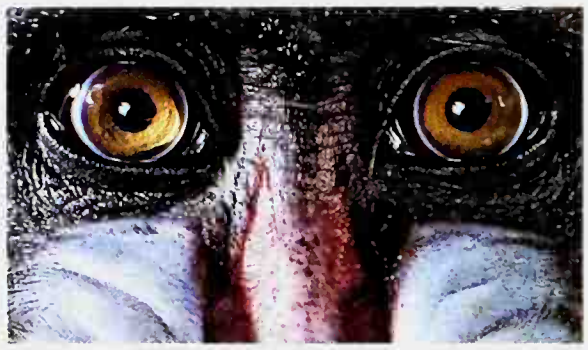
JAVAN LANGUR
Trachypithecus auratus
Most males and females of this species are black in color. However, some individuals retain their juvenile orange coloration into adulthood.

MANDRILL
Mandrillus sphinx

The mandrill is the largest of all monkeys, and the male is particularly spectacular. Mandrills live in troops that usually contain a dominant male, several females, a gaggle of youngsters, and various nonbreeding, lower-ranking males. Sometimes several groups merge to form troops of 200 or more. Mandrill society has a strict hierarchy. Individuals advertise their status with colorful patches of skin on the face and rump. A dominant male is fearsome-looking, and he has a temperament to match. The brightness of the skin pigments is controlled by hormones, and color is a good indicator of strength and ferocity. A rival must be very sure of himself before challenging such a magnificent animal, and serious fights tend to occur only between well-matched individuals.

SIZE 25–32 in (63–81 cm)
HABITAT Dense rain forest
DISTRIBUTION Western Central Africa, from Nigeria to Cameroon
DIET Mainly fruit

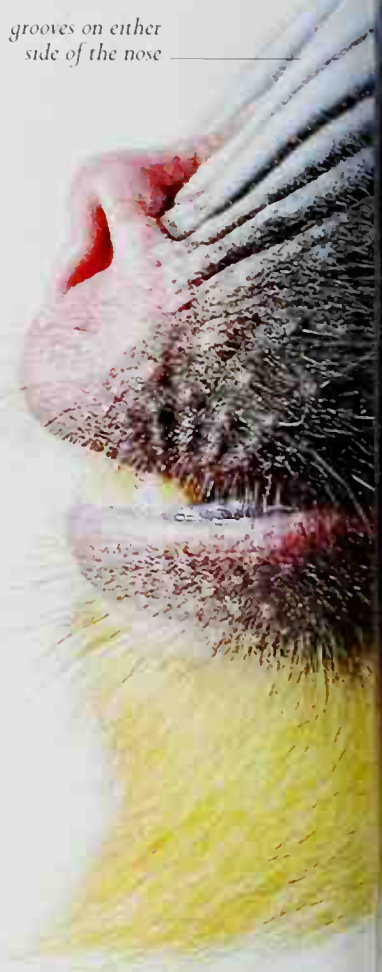
v LONG, HARD GLARE
Forward-facing eyes provide the mandrill with stereoscopic vision. They see in full color, which helps them locate ripe fruit and to distinguish the visual signals of other individuals.



< NOSTRILS
In a mature male, the skin around the nostrils and the center of the snout is scarlet. Females and young mandrills have a black nose.

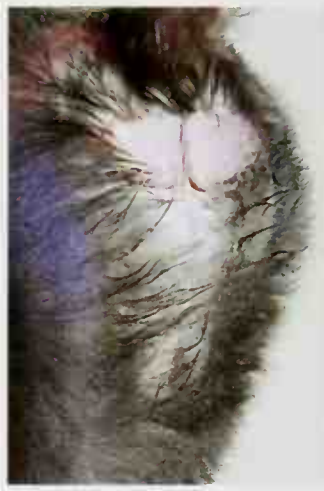
< TEETH
The long canine teeth are used principally for fighting and in display. The cheek teeth are smaller, with knobbly surfaces, which are used for grinding up plant material.

grooves on either side of the nose



^ GRASP
Mandrill thumbs are short, but fully opposable—like those of the great apes—for grasping and manipulating objects. The fingers are long and very strong, with stout nails.

^ HIND FEET
The hind feet resemble the hands, in that the toes are long and able to grasp. Mandrills are good climbers, and often sleep among the branches of trees.



^ PLAIN RUMP
All mandrills have a hairless rump and a short tail. The rump of the subordinate male has less color than the alpha male.

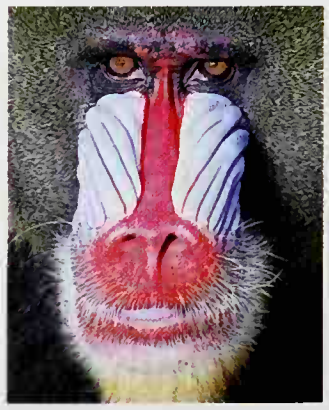
short, tufted tail

relatively short hind legs

ALL FOURS >
Mandrills spend most of their time at ground level, where they move around on all fours, and typically roam 3–6 miles (5–10 km) a day.

long, powerful arms

ALPHA MALE >
The skin color displayed by an individual changes depending on breeding condition and mood. The alpha male displays the most vivid red and blue hues on its face and rump.



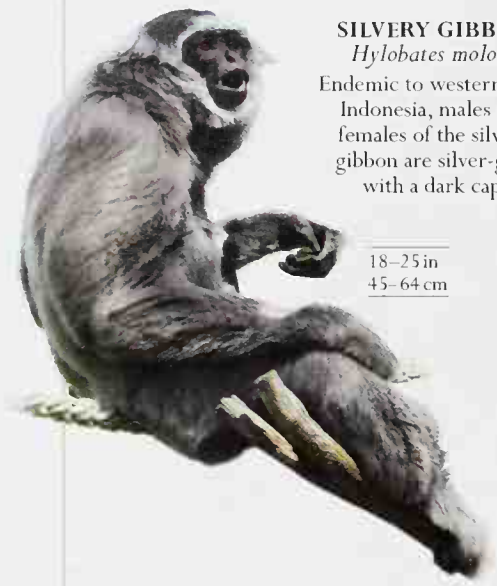
> POWERFUL PROFILE
The mandrill's head is bulky, accommodating powerful jaw muscles needed to crush tough plant foods. Its ears are relatively small, though it has excellent hearing. Only high-ranking males have an orange beard.

GIBBONS

The gibbons, or lesser apes, of the family Hylobatidae are medium-sized fruit-eating primates. They have no tail and characteristically move by brachiation—swinging between trees using their very long forearms. Gibbons usually form monogamous pair bonds that are reinforced by duetting songs, which also serve to announce territorial ownership. Some species have enlarged throat sacs to amplify the sound.

AGILE GIBBON
Hylobates agilis
Although its coat coloration varies, all agile gibbons have white eyebrows, and males also have white cheeks. This species lives in Thailand, Indonesia, and Malaysia.

18–25 in
45–64 cm



SILVERY GIBBON
Hylobates moloch
Endemic to western Java, Indonesia, males and females of the silvery gibbon are silver-gray with a dark cap.

18–25 in
45–64 cm

17½–25 in
44–64 cm

MULLER'S BORNEAN GIBBON
Hylobates muelleri
Also known as the gray gibbon, this species lives in Borneo. Monogamous pairs spend an average of 15 minutes per day singing duets.

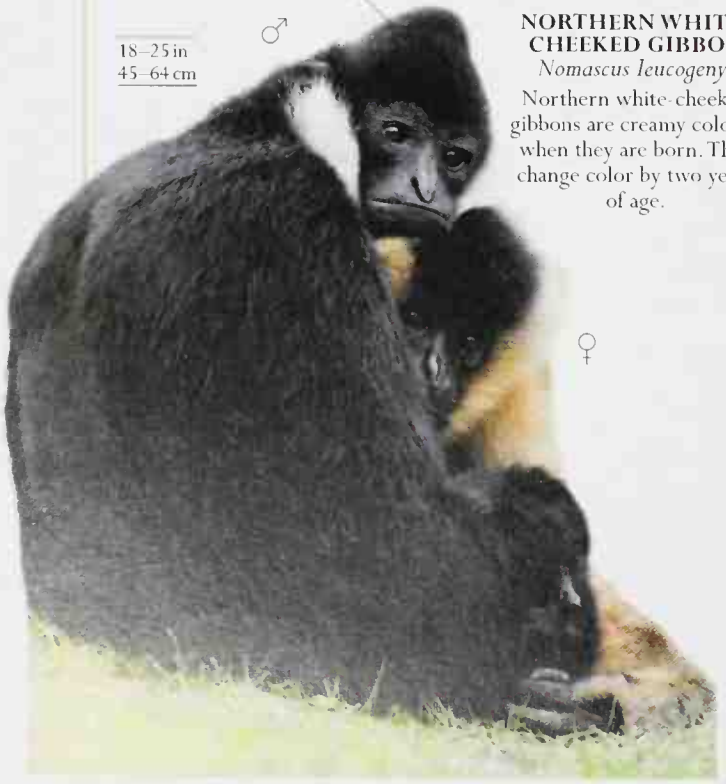
PILEATED GIBBON
Hylobates pileatus
Female pileated gibbons are silver-grey with a black face, chest, and cap; males are black. They are found in Thailand, Cambodia, and Laos.

17½–25 in
44–64 cm

18–25 in
45–64 cm

HOOLOCK GIBBON
Bunopithecus hoolock
Male hoolock gibbons are black, but females are tan with dark brown cheeks. They are found in China, northeast India, and northwest Myanmar.

16½–23 in
42–59 cm



18–25 in
45–64 cm

NORTHERN WHITE-CHEEKED GIBBON
Nomascus leucogenys
Northern white-cheeked gibbons are creamy colored when they are born. They change color by two years of age.

18–25 in
45–64 cm

BUFF-CHEEKED GIBBON
Nomascus gabriellae
Male buff-cheeked gibbons are black with pale cheeks; females are buff with a black cap. They are found in Cambodia, Laos, and Vietnam.

LAR GIBBON
Hylobates lar
Variable in coat coloration, the white-handed or lar gibbon lives in forests in Thailand, Malaysia, Sumatra, Myanmar, and Laos.

28–35 in
71–90 cm

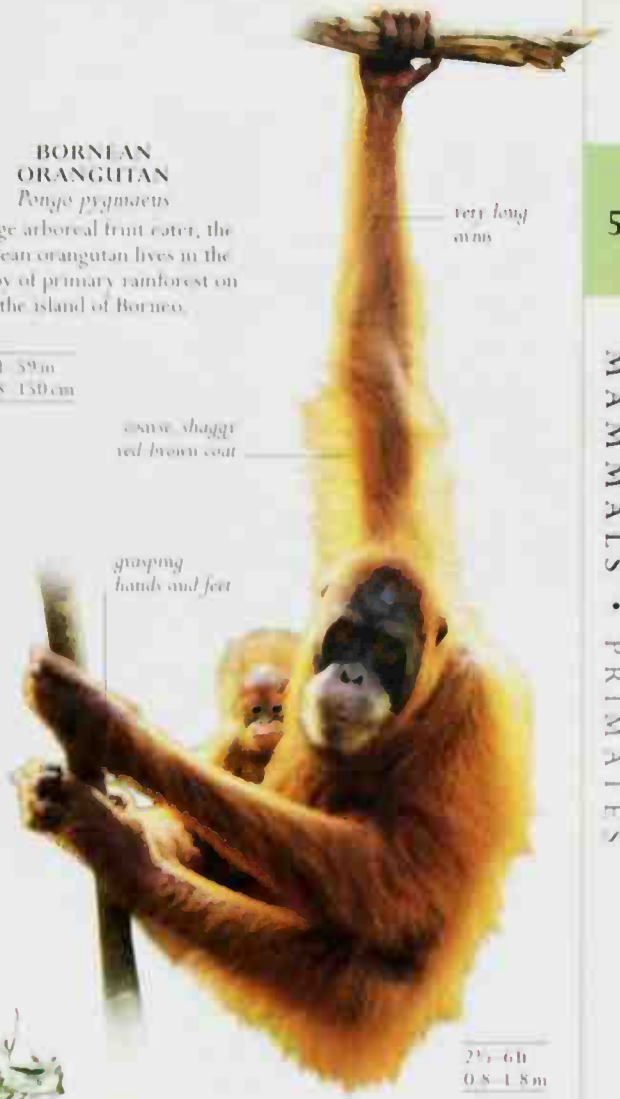
SIAMANG
Symphalangus syndactylus
The largest of the gibbons, the siamang lives on the island of Sumatra, Indonesia, and on the Malay Peninsula.

HUMANS AND APES

The family Hominidae contains the largest primates—the great apes and humans. Orangutans are arboreal, whereas chimpanzees, gorillas, and humans spend the majority of their time on the ground. Chimpanzees and gorillas move on all fours by "knuckle-walking." None of the great apes has a tail. Males are generally larger than females, and all species have relatively large braincases.

BORNEAN ORANGUTAN
Pongo pygmaeus
A large arboreal fruit eater, the Bornean orangutan lives in the canopy of primary rainforest on the island of Borneo.

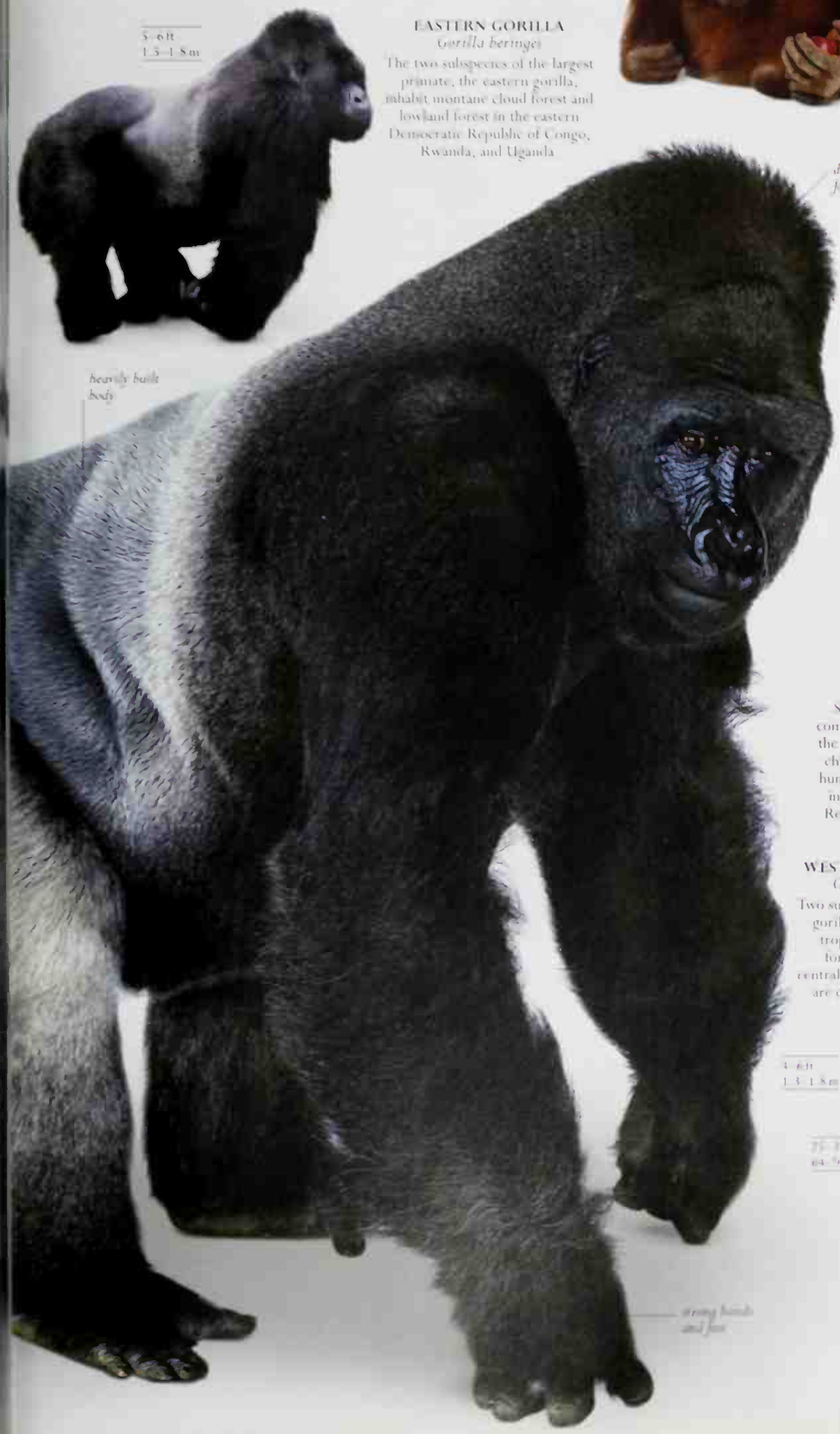
31–59in
78–150cm



2½–6ft
0.8–1.8m

5–6ft
1.5–1.8m

EASTERN GORILLA
Gorilla beringei
The two subspecies of the largest primate, the eastern gorilla, inhabit montane cloud forest and lowland forest in the eastern Democratic Republic of Congo, Rwanda, and Uganda.



28–33in
70–83cm

SUMATRAN ORANGUTAN
Pongo abelii
The largest arboreal primate, the Sumatran orangutan is restricted to fragments of primary tropical forest in northern Sumatra, Indonesia.

BONOBO
Pan paniscus
Slighter than the common chimpanzee, the bonobo or pygmy chimpanzee lives in humid tropical forest in the Democratic Republic of Congo.

4–7ft
1.2–2.1m

WESTERN GORILLA
Gorilla gorilla
Two subspecies of western gorilla live in lowland tropical and swamp forests in western central Africa. Adult males are called silverbacks.

4–6ft
1.3–1.8m

35–37in
64–94cm

COMMON CHIMPANZEE
Pan troglodytes
Four subspecies of the common chimpanzee are distributed in dry and moist forests and savanna woodlands in equatorial Africa.

HUMAN
Homo sapiens
Characterized by a bipedal posture and a lack of body hair, humans permanently inhabit every terrestrial habitat, with the exception of Antarctica.

BATS

The only mammals capable of powered flight, bats are primarily nocturnal. Many species use echolocation to navigate and find food.

Bats are found worldwide in many different habitats, including tropical, subtropical, and temperate forests, savanna grasslands, deserts, and wetlands. The order is often divided into two suborders—Megachiroptera ("megabats") and Microchiroptera ("microbats"). Most megabats are fruit-eaters, while most microbats eat insects. However, some bats drink nectar and eat pollen, a few suck blood, and some eat vertebrates, such as fish, frogs, and bats.

Their greatly elongated arm, hand, and finger bones support an elastic wing membrane for flight. Many bats also have a tail membrane between their legs. Bats typically rest upside down, hanging from their strong toes and claws.

THE SENSE OF ECHOLOCATION

Megabats rely predominantly on vision and smell, whereas microbats use a specialized sense called echolocation to avoid hitting objects, and to detect prey in the dark. They emit pulses of sound through their mouth or nose and form a "sound" image of their surroundings from returning echoes. Those species that emit echolocation calls through their noses usually have elaborate facial ornamentation, called noseleaves, for focusing the sound. Bats have very sensitive hearing, often highly tuned to the frequency of their returning echoes. Some species listen to prey-generated sounds, such as the rustle that an insect makes when walking on a leaf.

HABITS AND ADAPTATIONS

Bats are very social animals, living in colonies of hundreds or thousands and, exceptionally, millions of animals. They roost in trees and caves or in buildings, bridges, and mines. Temperate species either migrate to warmer climates or hibernate during winter. They may also become torpid if food becomes short in other seasons. Many interesting reproductive adaptations have developed, including the storage of sperm, delayed fertilization, and delayed implantation to ensure that the young are born at the optimum time of year.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	CHIROPTERA
FAMILIES	18
SPECIES	900+

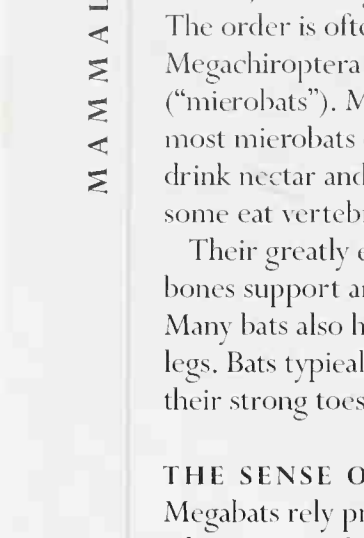
DEBATE

EVOLUTIONARY PUZZLES

Morphological and genetic analyses of the relationships between bat families do not always agree with one another. For example, although megabats share some features with primates that might suggest a separate evolutionary origin, genetic studies uphold the premise that all bats evolved from one common ancestor and that flight evolved only once. Molecular studies also show that advanced echolocators, such as the horseshoe bats, may be related to the nonecholocating fruit bats—an apparent conundrum unless echolocation has evolved twice or has later been lost in the fruit bats.

FRUIT BATS

The bats of the family Pteropodidae are distributed across the tropical and subtropical regions of the Old World. They have doglike faces with simple ears and large eyes. Most use vision and smell to locate their food, but members of the genus *Rousettus* echolocate by producing tongue clicks. These bats feed on fruits, nectar, and pollen. They have claws on both the thumb and the second finger.



2–3 in
5–7.5 cm

BLOSSOM BAT
Syconycteris australis
This specialized nectar-feeder occurs from Papua New Guinea to eastern coastal Australia. It has a pointed muzzle and a brush tipped tongue for probing flowers.

elastic skin membrane

4¼–7 in
11–18 cm

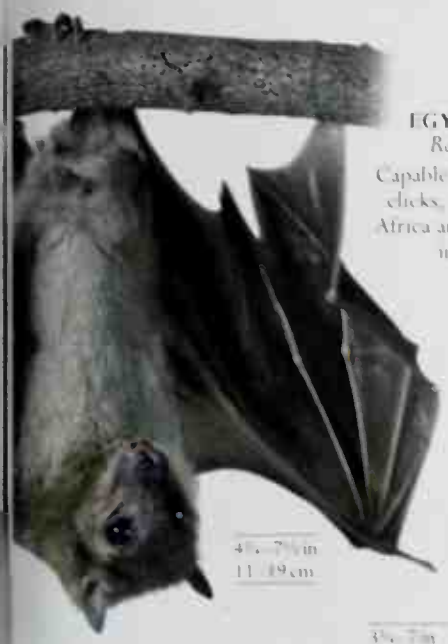
FRANQUET'S EPAULETTED BAT
Epomops franqueti
Also called the singing fruit bat because of the high-pitched call of the males, this species occurs in West and central Africa.

2¼–3¼ in
6–8.5 cm

LONG-TONGUED FRUIT BAT
Macroglossus minimus
Occurring in Southeast Asia, this fruit bat feeds on nectar and pollen from flowers, using its long tongue.

2¾–5 in
7–13 cm

SHORT-NOSED FRUIT BAT
Cynopterus sphinx
This is the only fruit bat that makes tents from palm leaves. It is found across Southeast Asia and the Indian subcontinent.



4¼–7½in
11–19cm

EGYPTIAN ROUSETTE
Rousettus aegyptiacus
Capable of echolocating by tongue clicks, this species occurs across Africa and the Middle East, except in the Sahara Desert.

3½–7in
9–17.5cm

GEOFFROY'S ROUSETTE
Rousettus amplexicaudatus
Like other *Rousettus* species, this Southeast Asian bat eats fruit and nectar. It roosts together with thousands of others in caves.

4–9¾in
10–24cm

MOLUCCAN NAKED-BACKED FRUIT BAT
Dobsonia moluccensis
Widespread in the Moluccan Islands, this bat is rare in the far north of Australia.

5–10in
12.5–25cm

WAHLBERG'S EPAULETTED FRUIT BAT
Epomophorus wahlbergi
Found in forests and savanna across sub-Saharan Africa, this species has white patches on its shoulders and eyebrows.

hind limbs have hooklike claws for roosting

5½–9in
14–22cm

AFRICAN STRAW-COLORED FRUIT BAT
Eidolon helvum
Colonies of this fruit bat can contain one million individuals. This migratory species is widespread in sub-Saharan Africa.

large eyes assist in navigation

thick leg fur down to ankle

7½–11in
19.5–28cm

LITTLE RED FLYING FOX
Pteropus scapulatus
This nomadic species from Australia primarily feeds on eucalyptus blossoms. It is occasionally found in Papua New Guinea.

webbed hind fingers

5–8in
13–20cm

10–14in
25–35cm

RODRIGUES FLYING FOX
Pteropus rodricensis
An inhabitant of mangrove and rain forest, this flying fox is found only on Rodrigues Island in the Indian Ocean.

6–8in
15–20cm

LYLE'S FLYING FOX
Pteropus lylei
Occurring in Cambodia, Thailand, and Vietnam, the Lyle's flying fox can severely damage trees by stripping them of their leaves.

14–18in
35–45cm

LARGE FLYING FOX
Pteropus vampyrus
The largest of all bats, this flying fox is found across the mainland and islands of Southeast Asia.

16–18in
41–45cm

INDIAN FLYING FOX
Pteropus giganteus
Found throughout India and parts of Southeast Asia, this species roosts in large colonies in forests and swamps.

9–10in
24–26cm

BLACK FLYING FOX
Pteropus alecto
The black flying fox has a wingspan of more than three feet. It lives in Indonesia, New Guinea, and northern Australia.

9–10in
22–25cm

SPECTACLED FLYING FOX
Pteropus conspicillatus
This fruit bat inhabits primary and secondary tropical rain forests in Indonesia's Moluccan Islands, New Guinea, and northeastern Queensland, Australia.

9–11¾in
23–29cm

GREY-HEADED FLYING FOX
Pteropus poliocephalus
The largest bat in Australia, this flying fox lives in communal roosts, known as camps, in rain forest and woodland.

LYLE'S FLYING FOX
Pteropus lylei

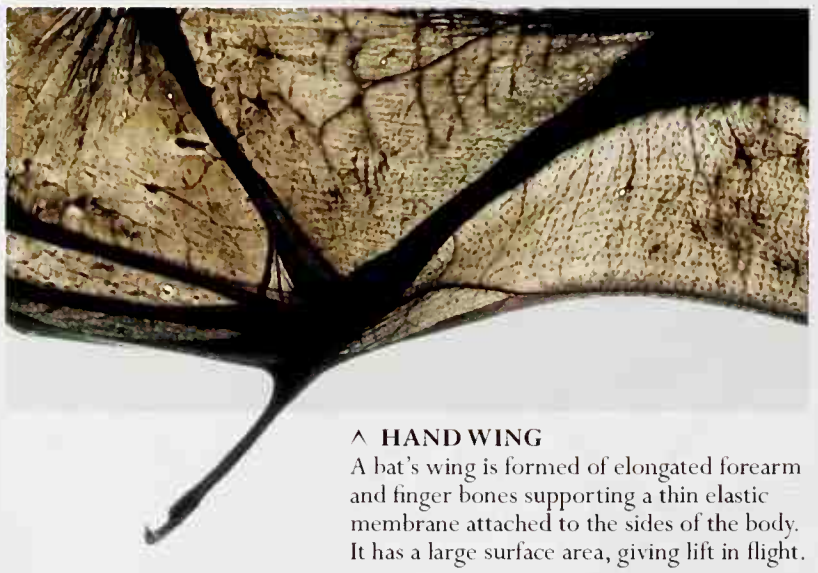
Lyle's flying fox is a medium-sized representative of the Old World fruit bat family, the Pteropodidae. Fruit bats are social animals; many hundreds may gather in roost trees during the day to rest and groom, dispersing at dusk to find ripe fruit. Although they may cause some damage to trees, many fruit bats are important pollinators and seed dispersers of tropical plants, including many commercial crops. Fruit bats are found in the tropical regions of Africa, Asia, and Australia, although this species is only found in Cambodia, Thailand, and Vietnam. They inhabit forested areas, including mangroves and fruit orchards.

SIZE 6–8 in (15–20 cm)
HABITAT Forests
DISTRIBUTION Southeast and East Asia
DIET Fruits and leaves

all bats have a thumb claw, but only Old World fruit bats have a claw on the second finger too

∨ CANINE FACE
Fruit bats have large eyes for navigation and large noses for sniffing out fruit, pollen, and nectar—giving them doglike faces. Species that use echolocation have larger ears and smaller eyes.

< CLINGING CLAWS
Bats' sharp, curved claws are perfect for clinging to tree branches. When roosting, tendons lock in place to ensure that the claws stay bent without the muscles needing to contract.



^ HAND WING
A bat's wing is formed of elongated forearm and finger bones supporting a thin elastic membrane attached to the sides of the body. It has a large surface area, giving lift in flight.

^ TAIL OR NO TAIL?
Pteropus bats lack tails, but some have a partial membrane supported by cartilaginous spurs called calcars, which protrude from the ankle.

WALKING UPSIDE DOWN >
Fruit bats use their large clawed thumb to help them move along the branches of their roost tree. The claw can also be used to manipulate fruit when feeding.

^ WELL WRAPPED
When resting, most fruit bats hang upside down with their leathery wings folded around their bodies. Bats roosting in the open risk overheating, so they flap their wings and cover themselves in saliva to help keep cool in hot weather.

reddish brown, foxy coloring
large eyes are adapted for excellent vision, especially at night
upright, foxlike ears detect sounds beyond the range of human hearing

< HANGING AROUND
Few bats are able to move well on the ground, let alone take off from a flat surface. By hanging upside down they are able to take flight quickly. During the day, they hang upside down to sleep, nestled together for warmth.

HORSESHOE BATS

Species of the family Rhinolophidae are distributed throughout southern Europe, Africa, Asia, and Australasia. Their noseleaf is characteristically horseshoe-shaped. They have the most sophisticated echolocation of all bats, involving highly specialized sound transmission and reception.

LESSER HORSESHOE BAT
Rhinolophus hipposideros
Found across Europe, North Africa, and western Asia, the lesser horseshoe bat is one of the smallest bats in the world.

1½–1¾ in
3.5–4.5 cm

2¼–2½ in
5.5–6.5 cm

MEHELY'S HORSESHOE BAT
Rhinolophus mehelyi
A cave-dwelling, medium-sized rhinolophid, this bat is patchily distributed across southern and eastern Europe and the Middle East.

2¼–2¾ in
5.5–7 cm

GREATER HORSESHOE BAT
Rhinolophus ferrumequinum
The largest of the European horseshoe bats, this species' range extends from Europe eastward across Asia to Japan.

LEAF-NOSED BATS

Found throughout much of Africa, Asia, and Australasia, the Hipposideridae contains the Old World leaf-nosed bats. They have complex noseleaves and, as with horseshoe bats, their hind legs are poorly developed, making them unable to move quadrupedally.

4¼–5¾ in
11–14.5 cm

3–3½ in
8–9 cm

COMMERSON'S LEAF-NOSED BAT
Hipposideros commersoni
This forest-dwelling bat roosts in hollow trees across the island of Madagascar. It is one of the largest leaf-nosed bats, weighing up to 6¼ oz (180 g).

SUNDEVALL'S LEAF-NOSED BAT
Hipposideros caffer
A savanna species, this leaf-nosed bat roosts in caves and buildings throughout Africa except in the Sahara and central forested regions.

MOUSE-TAILED BATS

The tails of of these bats are nearly as long as their bodies and are a distinguishing feature of the family Rhinopomatidae. Mouse-tailed bats also have fleshy muzzles, and their large simple ears join at the base.

2–3½ in
5–9 cm

MOUSE-TAILED BAT
Rhinopoma sp.
Four species of fast-flying insectivorous mouse-tailed bat live in arid and semiarid regions of North Africa, the Middle East, and India.

HOG-NOSED BAT

The sole member of the family Craseonycteridae, the tiny hog-nosed bat has long broad wings that allow it to hover. It lacks a tail and calcars (cartilaginous extensions of the ankle).

1–1¼ in
3–3.5 cm

KITTI'S HOG-NOSED BAT
Craseonycteris thonglongyai
One of the world's smallest mammals, and often called the bumblebee bat, Kitti's hog-nosed bat lives in riverside caves in Thailand and Myanmar.

SLIT-FACED BATS

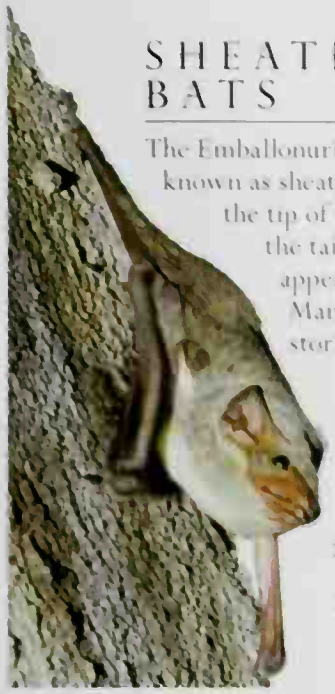
The slit-faced bats of the family Nycteridae have a furrow from their nostrils to a pit between their eyes. The cartilage at the end of their tail ends in a "Y" shape.

2–2½ in
5–6.5 cm

MALAYAN SLIT-FACED BAT
Nycteris tragata
The facial furrow of this slit-faced bat helps direct its echolocation calls. It is found in tropical forest in Myanmar, Malaysia, Sumatra, and Borneo.

SHEATH-TAILED BATS

The Emballonuridae are more commonly known as sheath-tailed bats because just the tip of their tail protrudes through the tail membrane, giving it the appearance of being sheathed. Many have glandular odor-storing sacs on their wings.



3½–4 in
9–10 cm

HILDEGARDE'S TOMB BAT
Taphozous hildegardeae
Dependent on caves for roosting, Hildegarde's tomb bat feeds on insects in the coastal forests of Kenya and Tanzania.

1½–2 in
4–5 cm

LESSER SHEATH-TAILED BAT
Emballonura monticola
The short tail of this bat appears to retract into a sheath when it stretches its legs. It lives in Indonesia, Malaysia, Myanmar, and Thailand.

1½–2 in
3.5–5 cm

PROBOSCIS BAT
Rhynchonycteris naso
These bats spend the day roosting in groups on the underside of branches. They live in tropical forest in Central and South America.

3–3½ in
7.5–8 cm

GREATER SAC-WINGED BAT
Saccopteryx bilineata
Male greater sac-winged bats attract females by a pungent secretion in their wing sacs. The species is found in Central and South America.

AMERICAN LEAF-NOSED BATS

The Phyllostomidae contains species that are distributed from southwestern USA to northern Argentina. Most have large ears and a noseleaf, shaped like a spearhead, to enhance echolocation.

3¼ in / 8.5 cm

PALE SPEAR-NOSED BAT
Phyllostomus discolor
This species emits echolocation calls through its nose. It is found in Central and northern South America.

2½–2¾ in
6–6.5 cm

COMMON TENT-MAKING BAT
Uroderma bilobatum
Found in lowland forests from Mexico to central South America, this bat creates shelters by biting palm and banana leaves.

2½–3½ in
6.5–9 cm

FRINGE-LIPPED BAT
Trachops cirrhosus
The fringe-lipped bat catches frogs by listening for their calls. It lives in tropical forest in Central and northern South America.

2–2½ in
5–6.5 cm

WHITE-LINED BROAD-NOSED BAT
Platyrrhinus lineatus
Named for the white lines on its face and back, this broad-nosed bat roosts in damp forests of central South America.

2¾–4 in
7–10 cm

GERVAIS' FRUIT-EATING BAT
Artibeus cinereus
Preferring to roost in palm trees, Gervais' fruit-eating bat lives in South America, including Venezuela, Brazil, and the Guianas.

2–2½ in
5–6.5 cm

CALIFORNIAN LEAF-NOSED BAT
Macrotus californicus
Primarily hunting for moths by sight rather than echolocation, the Californian leaf-nosed bat lives in northern Mexico and the southeastern USA.

2–2½ in
5–6.5 cm

SEBA'S SHORT-TAILED BAT
Carollia perspicillata
Inhabiting moist evergreen and dry deciduous forests across much of Central and South America, this species is a generalist fruit eater.

2–2½ in
5–6.5 cm

GEOFFROY'S TAILLESS BAT
Anoura geoffroyi
A specialized nectar feeder, this species has a long muzzle, elongate cheek teeth, and a brush-tipped tongue. It lives in Central and South America.

SILKY SHORT-TAILED BAT
Carollia brevicauda
This leaf-nosed bat is widespread in Central America and the Amazon region. It helps restore degraded forests by dispersing the seeds of fruit trees.

3–3½ in
7–9 cm

COMMON VAMPIRE BAT
Desmodus rotundus
Famous for feeding on other mammals' blood, the common vampire bat occurs in a variety of habitats in Mexico and Central and South America.

MORMOOPIDAE

The family Mormoopidae contains the naked-backed and mustache bats. Several species have wings that join across their backs and a fringe of stiff hairs around the muzzle.

1½–2¼ in
4–5.5 cm

DAVY'S NAKED-BACKED BAT
Pteronotus davyi
Unlike most other bats, this bat's wing membranes meet across its back. It is found from Mexico to South America.

NOCTILIONIDAE

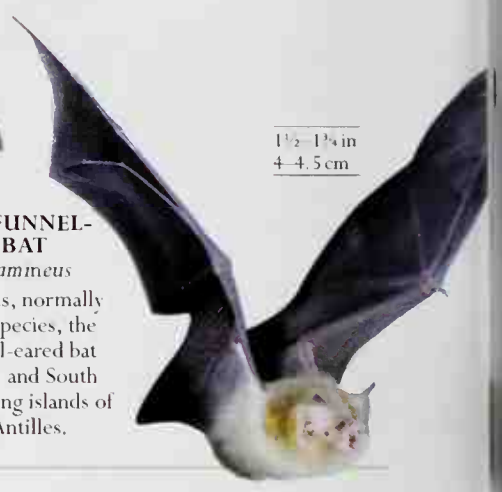
The two species of bulldog bats from the family Noctilionidae have long legs and large feet and claws. They have full lips and cheek pouches for storing food while flying.

4–5 in/10–13 cm

GREATER BULLDOG BAT
Noctilio leporinus
Specialized for snatching fish from the water's surface with its claws, the greater bulldog or fishing bat lives in tropical Central and South America.

NATALIDAE

The funnel-eared bats of the family Natalidae are small and slender with large ears. Adult males have a sensory structure, called a natalid organ, on their foreheads.

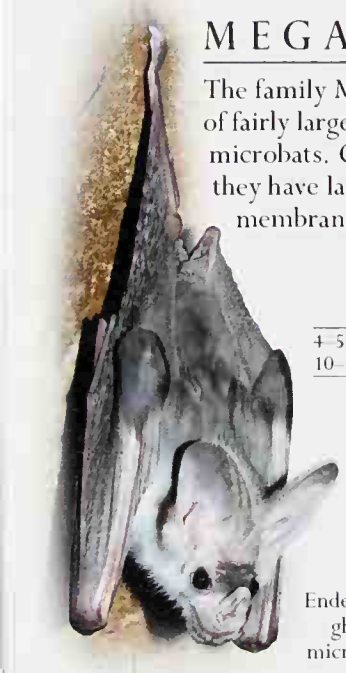


1½–1¾ in
4–4.5 cm

MEXICAN FUNNEL-EARED BAT
Natalus stramineus
An insectivorous, normally cave-roosting species, the Mexican funnel-eared bat lives in Central and South America, including islands of the Lesser Antilles.

MEGADERMATIDAE

The family Megadermatidae contains a handful of fairly large microchiropterans—echolocating microbats. Carnivorous and insectivorous, they have large ears and eyes and a broad tail membrane but little or no tail.



4–5 in
10–13 cm

GHOST BAT
Macroderma gigas
Endemic to northern Australia, the ghost bat is one of the largest microbats. It preys on vertebrates, such as frogs and lizards.

MYSTACINIDAE

The one extant member of the Mystacinidae has extra talons on its thumb and toe claws. Its tough, leathery wings can be folded against the body when moving on the ground.

2¼–3¼ in
6–8 cm

NEW ZEALAND SHORT-TAILED BAT
Mystacina tuberculata
An agile mover on the ground, the New Zealand short-tailed bat sniffs out prey in leaf litter on the forest floor.

THYROPTERIDAE

The family Thyropteridae contains three species of disk-winged bats. Suction cups on the wrists and ankles allow them to attach to smooth-surfaced tropical leaves when roosting.

1–2¼ in
2.5–5.5 cm

SPIX'S DISK-WINGED BAT
Thyroptera tricolor
An insectivorous inhabitant of lowland forests from southern Mexico to southeast Brazil, Spix's disk-winged bat roosts inside furled leaves.

MOLOSSIDAE

Free-tailed bats of the family Molossidae have a distinctive tail that extends beyond the edge of the tail membrane. They are robust, stocky bats with long narrow wings for fast flight. Their wing and tail membranes are particularly leathery.

3¼–3½ in
8–9 cm

EUROPEAN FREE-TAILED BAT
Tadarida teniotis
The only free-tailed bat to live in Europe, this bat's range extends from the Mediterranean to southern and southeast Asia.

3¾ in
9.5 cm

MEXICAN FREE-TAILED BAT
Tadarida brasiliensis
Colonies of the Mexican free-tailed bat roosting in caves and beneath bridges in Texas and Mexico can number in the millions.

3½–5½ in
9–14 cm

BROAD-EARED FREE-TAILED BAT
Nyctinomops laticaudatus
Occupying a range of different habitats, this free-tailed bat is found in tropical and subtropical Central and South America.

2–4½ in
5–11.5 cm

MILLER'S MASTIFF BAT
Molossus pretiosus
An insectivorous bat of lowland dry forests, open savanna, and cactus scrub, Miller's mastiff bat is distributed from Mexico to Brazil.

VESPERTILIONIDAE

Numbering more than 300 species, the Vespertilionidae is the largest family of bats. Known as evening or common bats, they are distributed worldwide excluding the polar regions, and are mostly insectivorous. They typically have plain noses and small eyes.

2–3¼ in
5–8 cm

SCHREIBERS'S BAT
Miniopterus schreibersii
Possessing long finger bones and broad wings, Schreiber's bat is patchily distributed in southwestern Europe and North and West Africa.

2¼–3¼ in
6–8 cm

1½–2¾ in
4–6 cm

4–5 in
10–13 cm

GREY LONG-EARED BAT
Plecotus austriacus
The grey long-eared bat's ears are almost the same length as its body. It lives in southern and central Europe and North Africa.

BIG BROWN BAT
Eptesicus fuscus
Often found roosting in buildings, the insectivorous big brown bat is distributed from southern Canada to northern Brazil and some Caribbean islands.

COMMON NOCTULE BAT
Nyctalus noctula
A fast and powerful flier with narrow, blackish brown wings, the noctule is found across northeast Europe and parts of Asia.

2–2½ in
5–6.5 cm

PARTI-COLOURED BAT
Vespertilio murinus
This pale-bellied, dark-backed bat is native to mountain, steppe, and forest habitats from eastern and central Europe to Asia.

1½–2 in
4–5 cm

NATTERER'S BAT
Myotis nattereri
From northwest Africa, across Europe to southwest Asia, Natterer's bat catches insects in its fringed tail membrane during a slow, hovering flight.

3–3¾ in
7.5–9.5 cm

1¾–2 in 4.5–5 cm

1¾–2¼ in 4.5–5.5 cm

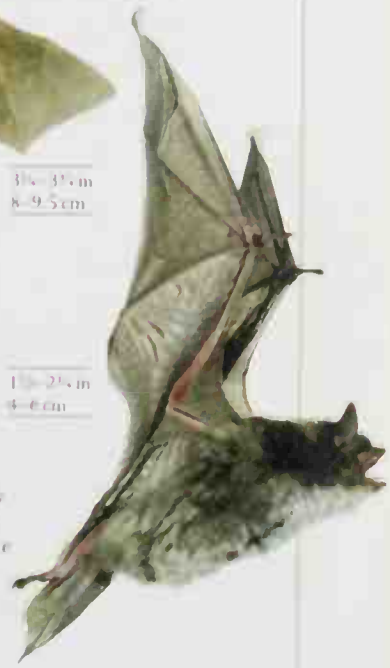
EASTERN PIPISTRELLE
Perimyotis subflavus
The eastern pipistrelle hibernates underground during winter. Its range covers eastern North America, from southern Canada to northern Honduras.

COMMON PIPISTRELLE
Pipistrellus pipistrellus
The most widespread pipistrelle species, the common pipistrelle's range extends from western Europe to the Far East and North Africa.

NATHUSIUS' PIPISTRELLE
Pipistrellus nathusii
A long-distance migrant capable of journeys of over 1,200 miles (1,900 km) in spring and fall, this species mainly occurs in eastern and central Europe.

3¼–3¾ in
8–9.5 cm

FRINGED MYOTIS
Myotis thysanodes
Named after a fringe of hairs along the edge of its tail membrane, this myotis bat lives in western North America.



1½–2¼ in
4–6 cm

DAUBENTON'S BAT
Myotis daubentonii
This Eurasian bat has relatively large feet, which help it catch flying insects emerging from the surface of bodies of water.

HEDGEHOGS AND MOONRATS

There is only one extant family of rather primitive mammals in the order Erinaceomorpha. Native to Eurasia and Africa, it includes the hedgehogs.

With long snouts, hedgehogs resemble—and were once classified with—the much smaller shrews and moles. Large eyes and excellent hearing reflect their crepuscular (active at dawn and dusk) or nocturnal habits. Their ears are often prominent, especially in desert species where they also serve to cool the animal. Generally with five toes on each foot, many species have sharp claws for digging burrows and shelters.

The 16 species of hedgehogs are covered in stout spines, made up of modified hairs. These provide an effective defense against predators, especially combined with their habit of rolling into a ball when threatened. In contrast, the eight moonrat species (also known as gymnures) are covered in normal fur and have longer, naked tails.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	ERINACEOMORPHA
FAMILIES	1
SPECIES	24

A VARIED DIET

All members of the order are described as omnivores, on the basis that their diet contains at least a small proportion of fruit and fungi, while hedgehogs in particular relish carrion and birds' eggs. However, the bulk of their diet is made up of living animals, from earthworms, mollusks, and other terrestrial invertebrates, to small reptiles, amphibians, and mammals. Food is detected by sight and their very keen sense of smell; the numerous, sharply pointed teeth are well suited to such a generalized diet.

Immunity to snake venom allows a hedgehog to take advantage of any snake it comes across as a potential food source.

HEDGEHOGS AND MOONRATS

With long, sensitive snouts and short, hairy tails, members of the family Erinaceidae eat almost anything, from invertebrates and fruit to birds' eggs and carrion. The hedgehogs, from Eurasia and Africa, are covered in sharp protective spines, while the southeast Asian moonrats have normal hair and look more like rats or opossums. Moonrats have especially well-developed scent glands that exude a strong garlicklike odor for marking territories.

6–8 in / 15–20 cm

SOUTHERN AFRICAN HEDGEHOG
Atelerix frontalis
Inhabiting grassland, scrub, and gardens in southern Africa, this species has a white band across its forehead, contrasting with its dark face.

7–10 in
18–25 cm

large ears

5½–11 in
14–28 cm

LONG-EARED HEDGEHOG
Hemiechinus auritus
Long ears help radiate heat and keep this nocturnal hedgehog cool in the deserts of North Africa and central Asia.

5½–11 in
14–28 cm

NORTH AFRICAN HEDGEHOG
Atelerix algirus
Found in varied habitats in the Mediterranean region, this long-legged hedgehog with a pale face and underparts has a spineless "parting" on its crown.

pale spines with darker bands

8–12 in
20–30 cm

DESERT HEDGEHOG
Paraechinus aethiopicus
This small African and Middle Eastern hedgehog is immune to the venom of snakes and scorpions, which form a large part of its diet.

12–16 in
30–40 cm

EUROPEAN HEDGEHOG
Erinaceus europaeus
Found throughout western Europe, this species inhabits woodland, farmland, and gardens. In cooler areas, it hibernates in a nest of leaves and grass.

MOONRAT
Echinosorex gymnura
Resembling a large rat, the nocturnal, white-coated moonrat lives in swamps and other wet habitats in Malaysia.

MOLES AND RELATIVES

The three families that make up the order Soricomorpha are insectivores, and have an elongated snout with sharp teeth, a long tail, and velvety fur.

About 90 percent of the species in the order Soricomorpha fall within just one family, the shrews (Soricidae). Members of this order are among the most primitive of the placental mammals, with small brains relative to their body size. There is also a considerable size range, from the tiny Etruscan shrew that weighs just $\frac{1}{16}$ oz (2 g) to the Cuban solenodon at $2\frac{1}{4}$ lb (1 kg).

Well adapted to their insectivorous way of life, the long, mobile, cartilaginous snout of shrews, moles, and solenodons contains numerous simple, sharp-pointed teeth, which they use to catch, kill, and dismember earthworms, other invertebrates, and even small vertebrates. In addition, some species produce venomous saliva, which runs along a groove in one of their lower incisor teeth, and helps subdue larger prey before it is killed and consumed.

SIMILAR BUT DIFFERENT

While most species in the order have short, velvety fur, the solenodons have a coarser, shaggy coat. Most also have a long tail, especially those species that forage in trees and bushes, where it provides balance. Many of the moles have only a short tail, one of several characteristics typical to mammals that have a tunneling way of life. Other features include small eyes and front limbs modified for digging.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	SORICOMORPHA
FAMILIES	3
SPECIES	428

A mother shrew is followed by her young. They form a chain, each holding on to the rear of the sibling in front of it.

SOLENODONS

Showing features of the earliest mammals, which evolved during the age of the dinosaurs 225–65 million years ago, the Solenodontidae resemble very large shrews. They have elongated, flexible, cartilaginous snouts; long, naked, scaly tails; small eyes; and coarse, dark fur. Unlike most mammals, they also have venomous saliva, which is used to subdue prey ranging from invertebrates to small reptiles.

13–13 in / 28–33 cm

HISPANIOLAN SOLENODON
Solenodon paradoxus
One of two extant species in its family, this solenodon is known only on Hispaniola, an island to the east of Cuba in the Caribbean.

shaggy, brown coat

CUBAN SOLENODON
Solenodon cubanus
With longer, finer fur than its Hispaniolan relative, this secretive, nocturnal burrower was erroneously believed to be extinct during the 20th century.

11–15 in / 28–39 cm

MOLES AND DESMANS

Small, dark insectivores with cylindrical bodies, short, dense fur, and very sensitive, hairless, tubular snouts, moles of the family Talpidae are well adapted for a life of burrowing—the forelegs have powerful claws, and the hands are turned permanently outward in the form of a shovel. In contrast, the aquatic desmans have webbed paws fringed with stiff hairs and long, flattened tails to aid in swimming.

6–8 in / 15–20 cm

STAR-NOSED MOLE
Condylura cristata
A semiaquatic North American mole, this species has 11 pairs of pink, fleshy appendages around its snout, which detect prey by touch.

4–5½ in / 10–14 cm

SMALL JAPANESE MOLE
Mogera imaizumii
This small mole from Japan is found in soft, deep soils, and is distinguished from close relatives by dental features.

4½ × 6¼ in / 11–16 cm

PYRENEAN DESMAN
Galemys pyrenaicus
Feeding in Pyrenean mountain streams, this desman rarely digs burrows; it shelters in rock crevices or the holes of water voles.

4½ × 6¼ in / 11–17 cm

EASTERN MOLE
Scalopus aquaticus
A burrowing mole from North America, typically in moist sandy soils, this species has ears and eyes covered by skin and fur respectively.

4½ × 6¼ in / 11–16 cm

EUROPEAN MOLE
Talpa europaea
Secretive due to its burrowing lifestyle, this mole creates extensive networks of permanent tunnels, often marked by distinctive surface molehills.

7–8 in / 18–21 cm

dense, waterproof coat

RUSSIAN DESMAN
Desmana moschata
The largest member of its family, this desman's webbed hind feet and long, flattened tail are adaptations for swimming in search of food.

SHREWS

With a pointed snout, velvety fur, a long tail, and sharp, simple teeth, members of the Soricidae are largely insectivorous, but also eat seeds, fruit, and carrion. Mostly terrestrial, they are highly active, needing to eat at least 80 percent of their own body weight daily. They have poor vision, but excellent senses of hearing and smell, and use echolocation to find their way around.

LESSER WHITE-TOOTHED SHREW
Crocidura suaveolens
Like others in its genus, this European species lacks the iron deposits that produce red tips on the teeth of many shrews.

2–3 in
5–7.5 cm

2¼–3¼ in
6–8 cm

REDDISH GREY MUSK SHREW
Crocidura cyanea
Males of this southern African forest shrew use a strong musky scent to mark their territories.

pale feet

3¼–4 in
8–10 cm

HOUSE SHREW
Suncus murinus
Native to southern Asia but introduced elsewhere in Asia and Africa, this adaptable, uniformly gray-brown shrew is often associated with human habitation.

3¼–4¾ in
8–12 cm

2–2¼ in
5–6 cm

PYGMY SHREW
Sorex minutus
Smaller than the common shrew, with which it often occurs, this species is distinguished by its relatively longer and hairier tail.

EURASIAN WATER SHREW
Neomys fodiens
The stiff hairs on its feet and tail improve the swimming efficiency of this large, sharply bicolored shrew, which hunts mainly in water.

2¼–4 in
6–10 cm

NORTHERN SHORT-TAILED SHREW
Blarina brevicauda
This large and venomous North American species usually forages in tunnels or under leaf litter or snow, rather than above ground.

2¼–3¼ in
5.5–8 cm

COMMON SHREW
Sorex araneus
The most common shrew in northern Europe, it is active day and night throughout the year, searching for food.

2¼–4 in
6–10 cm

1½–2 in
4–5 cm

CRAWFORD'S GRAY SHREW
Notiosorex crawfordi
From arid parts of North America, this shrew can survive without water. To conserve fluid, it produces highly concentrated urine.

2¼–3 in
6–7.5 cm

ALPINE SHREW
Sorex alpinus
The tail of this dark central European shrew is as long as its head and body. It aids balance when climbing trees.

short, dense, velvety fur

2–3¼ in
5–8 cm

NORTH AMERICAN LEAST SHREW
Cryptotis parva
A ferocious hunter, tackling large prey with venomous saliva, this species also bites lizards' tails. The shed tail provides an easy meal.

1½–2 in
3.5–5 cm

ETRUSCAN SHREW
Suncus etruscus
One of the smallest mammals, weighing only 1/16 oz (2 g), this shrew occurs in southern Europe and the Middle East, with closely related forms in Asia.

PANGOLINS

With bodies covered in large keratin scales, pangolins are also known as scaly anteaters, reflecting their appearance and diet.

Mainly nocturnal and with small eyes, pangolins use their excellent sense of smell to find food. Although somewhat similar in appearance to the American armadillos and sharing a similar diet, pangolins belong to a different order, Pholidota, and are most closely related to the carnivores.

The horny scales, which cover all exposed parts of the body, can make up one fifth of a pangolin's body weight; despite this, they are excellent swimmers. There are both terrestrial and arboreal species: ground-dwellers live in deep burrows, while tree-dwellers live in holes in trees.

Pangolins have powerful claws that are used to excavate insect nests. Food is captured on the sticky tongue, which extends up to 16 in (40 cm) from the toothless mouth. Because of the size of their front claws, pangolins walk on their wrists, the forepaws curled over to protect the claws.

SAFE FROM ATTACK

The scaly coat provides protection against predators, and is enhanced by the tendency of pangolins to roll into a ball when threatened or sleeping. Further defense is provided by their ability to emit a foul-smelling chemical from their anal glands. Nevetheless, pangolins are heavily exploited for their meat, scales, and perceived value in traditional Chinese medicine.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	PHOLIDOTA
FAMILIES	1
SPECIES	8

The long, sticky tongue of this African ground-dwelling pangolin is used for drinking as well as capturing insects.

MANIDAE

The eight pangolin species of the family Manidae live in tropical Africa and Asia. They are unique among mammals in having their skin protected by large horny scales. When threatened, they can curl up into a ball, the sharp plate edges providing additional defense. Large, powerful front claws are used to excavate ant hills and termite mounds in search of food, captured by sticky saliva on their long, probing tongues.

long fleshy nose

20–26 in
50–65 cm

30 scales on tail

SUNDA PANGOLIN
Manis javanica
Semiarboreal, this Asian pangolin moves clumsily on the ground, unless threatened, then it runs on its hind feet, using its tail for balance.

TREE PANGOLIN
Manis tricuspis
This arboreal pangolin from equatorial Africa has pale fur and distinctive three-pointed scales, although the points can become worn with age.

14–18 in
35–46 cm

LONG-TAILED PANGOLIN
Manis tetradactyla
This small pangolin from West Africa lives high in the forest canopy. It has a prehensile tail two-thirds of its total body length.

12–16 in
30–40 cm

18–30 in
45–75 cm

INDIAN PANGOLIN
Manis crassicaudata
Its overlapping scales and ability to emit a noxious defensive fluid can protect this pangolin even from the attentions of tigers.

broad, rounded scales

GROUND PANGOLIN
Manis temminckii
The only pangolin in southern and eastern Africa, this species is very secretive. It is hunted for its scales, which are used to make love charms.

16–28 in/40–70 cm

CARNIVORES

Predominantly meat-eaters, carnivores have bodies that are adapted for hunting and their teeth are specialized for grasping and killing prey.

The first carnivores evolved about 50 million years ago. They were small, tree-dwelling, rather catlike mammals, but their descendants, which include some of the largest predators on Earth, display a range of forms and lifestyles. The order Carnivora ranges in size from the least weasel, 5½ in (14 cm) long, to the southern elephant seal, which measures up to 23 ft (7 m) from nose to tail. The order includes the world's fastest land animal, the cheetah, and the famously idle giant panda. Carnivores are naturally present on every continent except Australia, where they have been introduced by man. They are not restricted to dry land—more than 30 species of seal and sea lion are more at home in the oceans.

CHARACTERISTICS

With such diversity, it can be difficult to ascertain what the animals of this order have in common. The most important shared characteristic of the group is their teeth. All members of Carnivora have four long canine teeth and a distinctive set of cheek teeth known as carnassials, which are modified for cutting meat. The sharp edges of the carnassials work like a pair of scissor blades when the animal opens and shut its jaws.

Most carnivores eat at least some meat, but few are exclusively carnivorous. Several species, such as the foxes and raccoons, are omnivores, eating a wide range of plant and animal foods. One species, the giant panda, is completely herbivorous, with a diet consisting mainly of bamboo.

SOLITARY OR SOCIAL

Carnivores may lead solitary lives, like most weasels and bears, or be highly social, like wolves, lions, and meerkats. Animals in the latter category live in highly organized cooperative groups, sharing responsibility for hunting, rearing young, and protecting their territory. Seals and sea lions are generally colonial during the breeding season, when they are obliged to return to dry land to mate and give birth; some species gather in hundreds or even thousands on favored beaches.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	CARNIVORA
FAMILIES	15
SPECIES	286

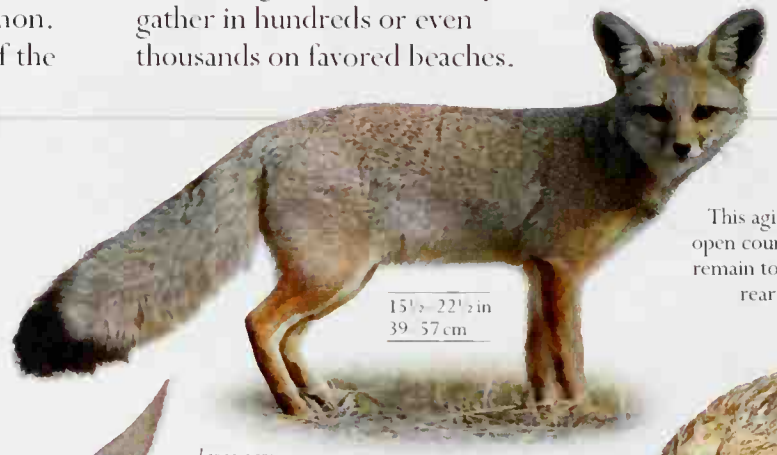
DEBATE

PINNIPED OR CARNIVORE?

Taken at face value, it seems unlikely that the aquatic seals, sea lions, and walruses, known as pinnipeds from the Latin for "web-footed," could belong to the same group as weasels and wildcats. But the structure of their skulls and teeth and the information coded in their DNA tells a different story. Pinnipeds have limbs modified for swimming, but—unlike whales—they are not wholly aquatic and must return to land in order to breed. Fossil and molecular evidence suggests that seals, sea lions, and the walrus share a common bearlike ancestor, which diverged from the other carnivores about 23 million years ago.

DOGS, FOXES, AND RELATIVES

The Canidae are medium-sized, long-legged mammals, most of which have a bushy tail and erect ears. They are swift, intelligent predators, although most also eat plant foods. The highly social gray wolf is the ancestor of the domestic dog, a species domesticated by man over 10,000 years ago, and now hugely varied in size and form.



15½–22½ in
39–57 cm

BENGAL FOX
Vulpes bengalensis
This agile, omnivorous fox inhabits open country in Nepal and India. Pairs remain together from year to year and rear several litters together.

short, pointed face

18–23½ in
45–60 cm

yellowish white underside

large ears

15–20 in
38–50 cm

BLANFORD'S FOX
Vulpes cana
A strictly nocturnal species, this fox inhabits steppe country of the Arabian Peninsula and the Middle East. It feeds upon invertebrates and fruits.

20–30 in
50–75 cm

ARCTIC FOX
Vulpes lagopus
This sturdy fox lives in the world's northernmost regions. Its variable color forms include snowy white.

CORSAC FOX
Vulpes corsac
A social, pack-dwelling animal of the Asian steppes, the Corsac fox is an opportunistic hunter of small animals. It also eats vegetable matter.

14½–20 in
37–50 cm

KIT FOX
Vulpes macrotis
Found in the southwestern USA, the kit fox is an efficient digger. Families live in burrows with up to 20 entrances.

SWIFT FOX
Vulpes velox
This close relative of the kit fox occurs in the central USA and has been reintroduced in Canada, where it became extinct in 1938.

14–21 in
37–54 cm

FENNEC FOX
Vulpes zerda
The distinctive ears of this tiny, nocturnal North African fox serve a dual purpose: providing keen hearing and shedding excess body heat.

pointed ears, black on top

13–16 in
33–41 cm

14–22 in
35–55 cm

RÜPPELL'S FOX
Vulpes rueppellii
Ranging from North Africa to Pakistan, this small, social fox survives desert conditions by eating a wide range of plants and animals.

large, bushy tail, with a white tip

RED FOX
Vulpes vulpes
This highly adaptable hunter and scavenger is the world's most widespread carnivore, occurring throughout most of the Northern Hemisphere.

20–35 in
50–90 cm

18–24 in
46–60 cm

black lower limb

BAT-EARED FOX
Otocyon megalotis
Inhabiting open grassland and scrubby savanna in southern and eastern Africa, this social fox feeds chiefly on termites and beetles.

PAMPAS FOX
Lycalopex gymnocercus
A native of temperate grassland in South America, this solitary fox hunts a variety of small animals and occasionally sheep.

20–29 in
50–74 cm

21–26 in
54–66 cm

GRAY FOX
Urocyon cinereoargenteus
This fox is a relatively common inhabitant of forested areas throughout the Americas, although it avoids areas where coyotes and bobcats live.

brown black body fur

19–28 in
49–70 cm

18–36 in
45–92 cm

CULPEO
Lycalopex culpaeus
A large, solitary fox from the highlands of South America, the culpeo hunts larger prey than most fox species.

23½–40 in
59–77 cm

CRAB-EATING FOX
Cerdocyon thous
An adaptable omnivore from the grasslands and temperate and tropical forests of South America, this species feeds on fruits, carrion, and small animals.

RACCOON DOG
Nyctereutes procyonoides
This unusual dog inhabits wetlands in eastern Asia. It climbs well and is the only species of dog to hibernate.

»

» DOGS, FOXES, AND RELATIVES

18–35 in
45–90 cm

BLACK-BACKED JACKAL
Canis mesomelas
The largest of the African jackals, this adaptable, omnivorous dog lives in family groups. It is active both day and night.

26–41 in
65–105 cm

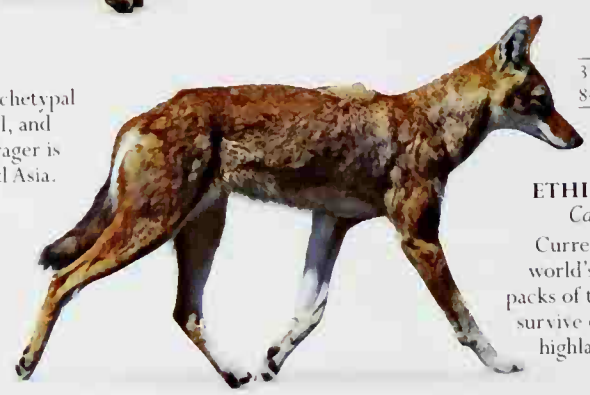
GOLDEN JACKAL
Canis aureus
Sometimes described as the archetypal dog, this swift footed, social, and opportunistic hunter and forager is widespread across Africa and Asia.

26–32 in
65–80 cm

SIDE-STRIPED JACKAL
Canis adustus
A widespread African jackal, this species is a nocturnal scavenger and hunter. It is often persecuted by farmers.

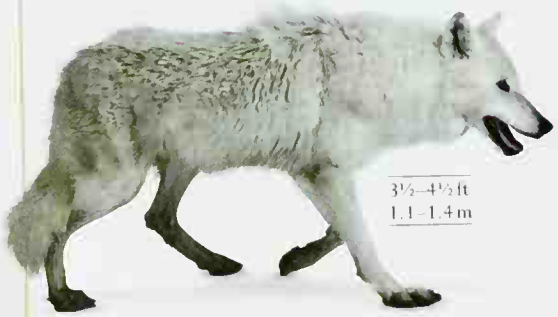
28–38 in
70–97 cm

COYOTE
Canis latrans
Native to North and Central America, this widespread and common species travels in packs and occasionally mates with the gray wolf.



33–39 in
84–101 cm

ETHIOPIAN WOLF
Canis simensis
Currently listed as the world's rarest dog, wild packs of this threatened wolf survive only in the remote highlands of Ethiopia.



3½–4½ ft
1.1–1.4 m

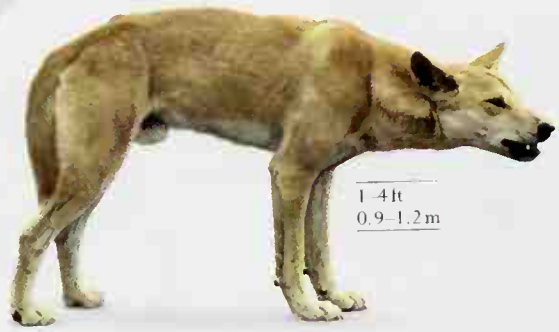
ARCTIC WOLF
Canis lupus arctcos
Distinguished by a pale coat, this subspecies of the gray wolf lives in parts of Canada, Alaska, and Greenland.

3¼–4 ft
1–1.2 m

RED WOLF
Canis lupus rufus
This highly endangered subspecies from the southeastern USA survives on special reserves, thanks to captive breeding in the 1980s.

3–5½ ft
0.9–1.6 m

GRAY WOLF
Canis lupus lupus
The ancestor of the domestic dog, this adaptable wolf has a vast distribution, covering most of the Northern Hemisphere.



1–4 ft
0.9–1.2 m

DINGO
Canis lupus dingo
This large subspecies of the gray wolf was introduced to Australia about 4,000 years ago, where it rapidly became the continent's top predator.

GOLDEN RETRIEVER
Canis lupus familiaris
Bred in Scotland to retrieve game, this dog is loyal and intelligent, and makes an excellent pet. It loves being in water.

2½–3½ ft
85–100 cm

23½ in
60 cm

BASSET HOUND
Canis lupus familiaris
This dog was bred as a tracking animal. Its short legs allow it to move easily through dense vegetation.

25–31 in
63–79 cm

DALMATIAN
Canis lupus familiaris
Initially bred as guard dogs and hunting companions, dalmatians subsequently became coach dogs, escorting horsedrawn carriages. Today they are kept as pets.

31–48 in
79–96 cm

MALAMUTE
Canis lupus familiaris
Bred in Alaska as a sled dog, the malamute resembles the ancestral wolf, and may be among the earliest domestic breeds.

MANED WOLF
Chrysocyon brachyurus
An opportunistic omnivore, the maned wolf inhabits South American savanna, where its long legs help it see over tall grasses.

3–4½ ft
1–1.3 m

16 in
40 cm

SMOOTH FOX TERRIER
Canis lupus familiaris
An enthusiastic digger and small enough to enter fox burrows, this lively dog was bred to keep farms free of vermin.

26–34 in
67–85 cm

ROUGH COLLIE
Canis lupus familiaris
Originally bred as a herding dog in the Scottish Highlands, this dog has an athletic build disguised by a thick coat.

8–12 in
20–30 cm

CHIHUAHUA
Canis lupus familiaris
The smallest of domestic dog breeds, but bold-natured nonetheless, the chihuahua originated in Mexico. Its coat can be of almost any color.

3–4½ ft
0.9–1.4 m

DHOLE
Cuon alpinus
Known throughout its Asian range as a fierce predator, this wild dog lives and hunts in packs, targeting large mammals, such as deer and goats.

2½–4½ ft
0.8–1.4 m

AFRICAN WILD DOG
Lycaon pictus
This endangered dog lives in highly organized packs, hunting and rearing young cooperatively and supporting sick and injured relatives.

22½–30 in
57–75 cm

BUSH DOG
Speothos venaticus
This distinctive, short-legged species is a predator of the Amazon region. It hunts mainly rodents, working alone or in a pack.

BEARS

The Ursidae are large, stocky-yet-agile animals native to Europe, Asia, and the Americas. Most bears are omnivorous, with plant material making up most of their diet. However, the polar bear is a specialized meat-eater and the giant panda, sometimes placed in a separate family, is an herbivore. Bears live alone except for mothers caring for their young.

BROWN BEAR
Ursus arctos

This bear's vast range, including North America, northern Europe, and Asia, demonstrates its dietary flexibility. Seasonal foods include berries and spawning salmon.

5–9¼ ft
1.5–2.8 m

five claws grow to 4 in (10 cm)

4–6 ft
1.2–1.8 m

white face with black eyes and ears

GIANT PANDA
Ailuropoda melanoleuca

This endangered bear lives in central Chinese forests. Despite being a carnivore, it eats mostly bamboo; this lack of adequate nutrition results in a low-energy lifestyle.

EARED SEALS

Members of this family are distinguished from true seals by their small external ears and by their limbs, which can be used for moving on land—they are able to walk on their flippers, albeit in an ungainly manner. The Otariidae are excellent swimmers, but their dives are short and shallow compared with those of some true seals. They occur in most oceans except the North Atlantic.

STELLER'S SEA LION
Eumetopias jubatus

Also known as the northern sea lion, this North Pacific species is the largest of the eared seals. It eats mainly fish, but may take smaller seals.

thick neck

4¼–8¼ ft
1.3–2.5 m

AUSTRALIAN SEA LION
Neophoca cinerea

This relatively rare species has breeding colonies restricted to Western and South Australia. Small groups stay together even outside the breeding season.

6½–11 ft
2–3.3 m

dark brown or black pup

black flippers

ADULT

JUVENILE

5¼–8¼ ft
1.6–2.5 m

NEW ZEALAND SEA LION
Phocarctos hookeri

Found only in the waters around New Zealand, this rare species breeds on just a few offshore islands.

6–8½ ft
1.8–2.6 m

4½–7¼ ft
1.4–2.2 m

doglike muzzle with whiskers

streamlined body tapers from shoulder to tail

CALIFORNIA SEA LION
Zalophus californianus

Widely recognized as the "performing seal," this species is agile on land and in water, often leaping partly clear of the surface.

5–8¼ ft
1.5–2.5 m

SOUTHERN SEA LION
Otaria flavescens

Thickset with a blunt face, this resident of South America and the Falkland Islands in the South Atlantic occasionally hunts cooperatively and may enter rivers in search of fish.

NORTHERN FUR SEAL
Callorhinus ursinus

Except when breeding, this species lives far offshore in the North Pacific. Males can be over five times as heavy as females.

4–6¾ ft
1.2–1.9m

AMERICAN BLACK BEAR
Ursus americanus
Numbering about 900,000 individuals across varied habitats in North America, this is the world's most common bear. Some have brown or blond fur.

3½–6¼ ft
1.1–1.9m

ASIATIC BLACK BEAR
Ursus thibetanus
A widespread forest-dweller, this bear is variable in appearance, habitat, and behavior. In the tropics, only pregnant females hibernate.

6–9¾ ft
1.8–2.8m

POLAR BEAR
Ursus maritimus
One of the largest predators on land, the polar bear is equally at home in water. It spends most of its life on Arctic sea ice.

3½–5ft
1–1.5m

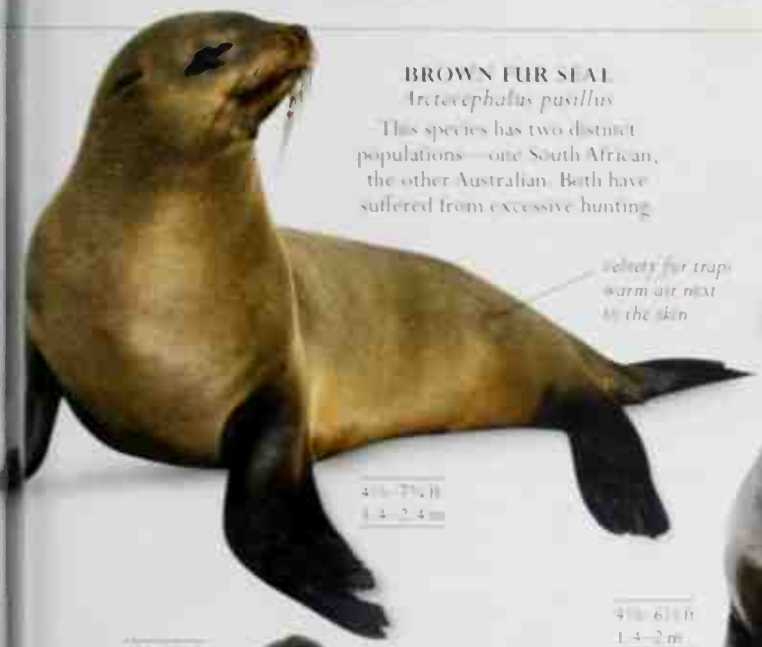
SUN BEAR
Helarctos malayanus
This shy Southeast Asian forest bear eats insects, honey, fruits, and plant shoots. It is active by day, becoming nocturnal if disturbed.

3½–6ft
1–1.8m

SPECTACLED BEAR
Tremarctos ornatus
A vulnerable species of Andean cloud forests, this bear is an excellent climber. Its varied diet includes fruits, shoots, and meat.

4½–6¾ ft
1.4–1.9m

SLOTH BEAR
Melursus ursinus
This shaggy Indian bear can live in a range of habitats. It uses its huge claws to open termite mounds, sucking up the panicking insects.



BROWN FUR SEAL
Arctocephalus pusillus
This species has two distinct populations—one South African, the other Australian. Both have suffered from excessive hunting.

4½–7¾ ft
1.4–2.4m

4–5¾ ft
1.2–1.6m

GALAPAGOS FUR SEAL
Arctocephalus galapagoensis
The smallest of the eared seals, this species is also the least variable, with males only slightly larger than females.

4½–6½ ft
1.4–2m

GUADALUPE FUR SEAL
Arctocephalus townsendi
Distinguished by its long, tapering nose, this fur seal breeds on rocky beaches and caves accessible only from the sea.

4¾–6½ ft
1.3–2m

ANTARCTIC FUR SEAL
Arctocephalus gazella
This species breeds on the scattered islands of the Southern Ocean. It is recovering from excessive hunting in the past.

4½–6¼ ft
1.4–1.9m

SOUTH AMERICAN FUR SEAL
Arctocephalus australis
This voracious predator of fish, squid, and crustaceans breeds on the rocky beaches of South America and the Falkland Islands.

AUSTRALIAN FUR SEAL
Arctocephalus forsteri
This seal breeds on the rocky coasts of New Zealand and Australia. Now protected by law, it is no longer hunted and its numbers are increasing.

4½–8¼ ft
1.4–2.5m

POLAR BEAR
Ursus maritimus

This magnificent animal is as at home at sea as on land. It is the world's largest terrestrial predator, and its huge bulk can make it seem lumbering. In the water, however, it is transformed into a creature of effortless grace. Polar bears are true nomads and spend much of the year far from land, roaming the frozen expanse of the Arctic Ocean. In summer the melting ice forces them to retreat to land, where they sometimes come into contact with humans. Young polar bears are born in the middle of winter in a hibernation den dug by their mother. She scarcely wakes from hibernation when they arrive, but nurses them in her sleep for three months, breaking down her own body reserves to create rich, fatty milk. Come the spring, the cubs have increased their birth weight dramatically, while the mother is close to starvation. She spends the next two years teaching them to swim, hunt seals, defend themselves, and build their own snow dens. Climate change is threatening the habitat and feeding habits of polar bears, which could result in the bears' extinction.

unlike other bears, the polar bear has a slightly convex "Roman" nose

SIZE 6–9¼ ft (1.8–2.8 m)
HABITAT Arctic ice fields
DISTRIBUTION Arctic Ocean; polar regions of Russia, Alaska, Canada, Norway, and Greenland
DIET Mainly seals

FURRY EARS >
The small ears are completely covered with fur to prevent frostbite. Polar bears have good hearing but rely mainly on their sense of smell to locate their prey.

< DARK EYE
The dark eyes and nose are the most conspicuous parts of the bear's body. Polar bears have good eyesight, comparable to that of humans.

^ CRUSHING BLOW
The front paws are the principle means of dispatching prey. With their excellent sense of smell, polar bears can detect young seals located in dens below the ice, and then crush them with a mighty blow from above.

^ PADDLE PAWS
The huge, furry-soled paws make effective paddles when swimming, propelling the bear at around 4 miles (6 km) per hour for hours at a time.

^ STUBBY TAIL
The polar bear has little use for a long tail, so the appendage is reduced to a stub—all but hidden in the dense fur.

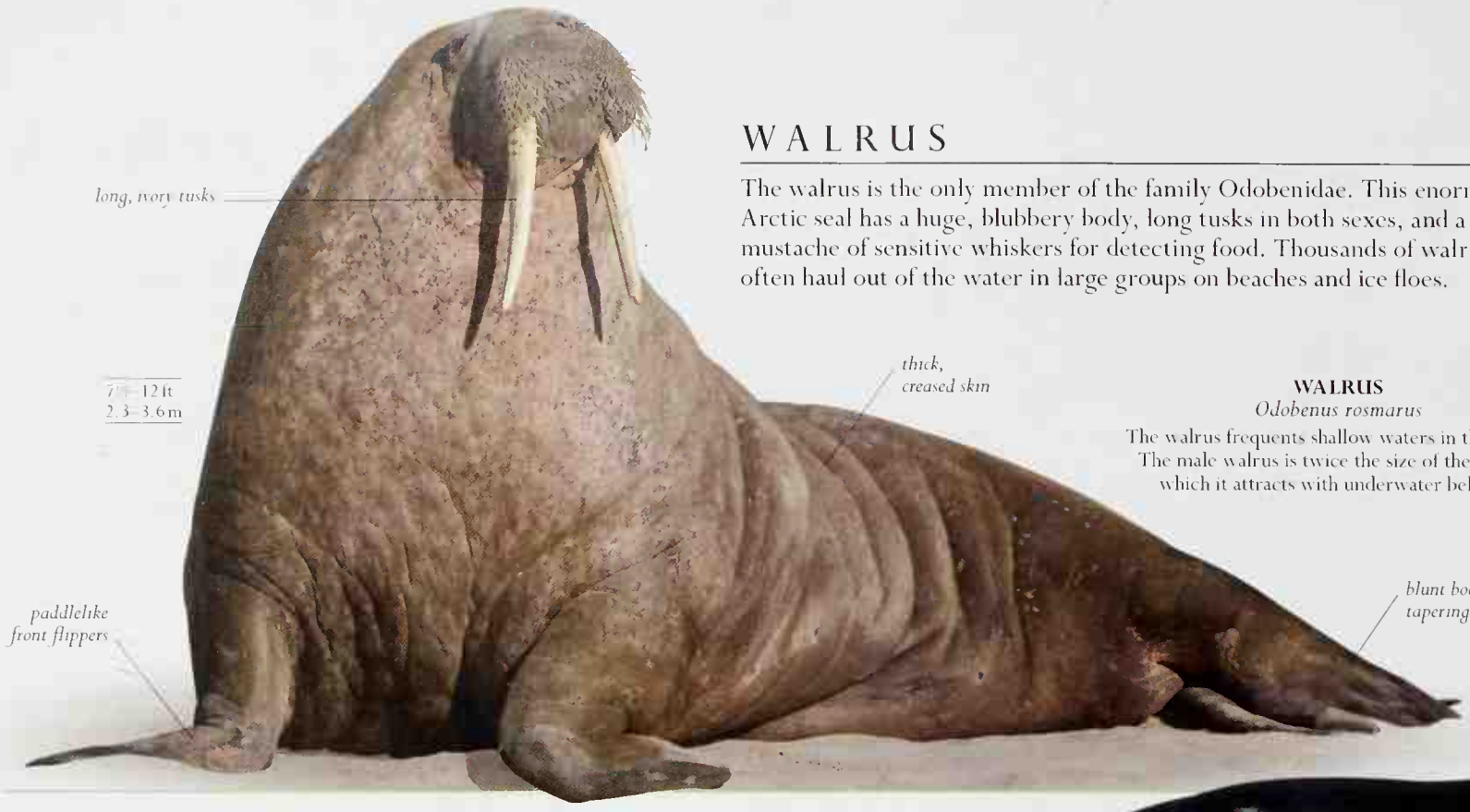
each hair is hollow, and air trapped inside the bear's coat enhances both insulation and buoyancy

fur is colorless, and reflects white light

^ MIGHTY BEAR
The largest polar bears weigh as much as 1,760 lb (800 kg), but much of their apparent bulk is due to their immensely thick fur. They are able to run in short bursts at speeds of up to 25 miles (40 km) per hour. They are an impressive sight, but there are fewer than 25,000 polar bears left in the wild, and their numbers are declining due to climate change.

WALRUS

The walrus is the only member of the family Odobenidae. This enormous Arctic seal has a huge, blubbery body, long tusks in both sexes, and a mustache of sensitive whiskers for detecting food. Thousands of walruses often haul out of the water in large groups on beaches and ice floes.



WALRUS
Odobenus rosmarus
The walrus frequents shallow waters in the Arctic. The male walrus is twice the size of the female, which it attracts with underwater bellows.

EARLESS SEALS

Also called true seals, the Phocidae are more adapted to life in water than their cousins, walruses and sea lions. In place of ear flaps, they have tiny holes on the sides of their heads. Their flippers are useless on land, but propel them with speed and agility in water. Mostly inhabiting cool temperate and polar waters, seals prey on fish and invertebrates, while leopard seals hunt penguins.

5½–8¼ ft
1.7–2.5 m

ROSS SEAL
Ommatophoca rossii
This rare, fast-swimming seal spends most of its life hunting squid beneath Antarctic pack ice. Males are smaller than females.

8¼–11 ft
2.5–3.3 m

WEDDELL SEAL
Leptonychotes weddellii
The most southerly dwelling wild mammal, this expert diver specializes in long, deep dives under Antarctic ice shelves. Females are larger than males.

8¼–11 ft
2.5–3.4 m

LEOPARD SEAL
Hydrurga leptonyx
This fearsome predator mostly ambushes smaller seals, fish, and penguins at the edge of Antarctic pack ice, although it also eats krill.

5½–11 ft
1.7–3.3 m

GRAY SEAL
Halichoerus grypus
The gray seal lives in the North Atlantic, with large numbers breeding on a small island off Nova Scotia. Males are up to three times as heavy as females.

6½–8½ ft
2–2.6 m

BEARDED SEAL
Erignathus barbatus
This large, Arctic seal feeds on bottom-dwelling fish and invertebrates, which it locates partly by touch, using its long, stiff whiskers.

6½–7¾ ft
2–2.4 m

HAWAIIAN MONK SEAL
Monachus schauinslandi
Along with its Mediterranean relative, this is one of only two surviving, highly endangered and protected species of monk seals. Fewer than 1,400 of this species remain.

5½–6¼ ft
1.7–1.9 m

HARP SEAL
Pagophilus groenlandicus
This small seal migrates south in winter and north in summer in noisy groups, following the Arctic pack ice, on which it hauls out and rests.

6½–7½ft
2–2.4m

CRABEATER SEAL
Lobodon carcinophagus
Despite its name, this agile Antarctic seal eats mainly krill, which it filters from the water, using specially modified teeth.

8½–8½ft
2–2.7m

inflatable muzzle of male

HOODED SEAL
Cystophora cristata
This solitary Arctic seal has an unusual, inflatable nose that droops over its mouth. The pups become independent at just five days old.

10½–16ft
3–5m

NORTHERN ELEPHANT SEAL
Mirounga angustirostris
This is a large seal of the North Pacific. The male has a long, trunklike nose. Like its southern relative, it was almost hunted to extinction, but is now recovering.

8½–25ft
2–7.5m

SOUTHERN ELEPHANT SEAL
Mirounga leonina
The huge male of this Southern Ocean species has a trunklike nose and is the largest carnivore, weighing up to 11,000lb (5,000kg).

4½–5½ft
1.4–1.7m

SPOTTED SEAL
Phoca largha
This small seal is mainly found on ice floes off the northern coasts of Siberia and Yukon, Canada. Adults form stable pairs in order to breed.

large eyes set back on head

4–6½ft
1.2–2m

spots, rings, and blotches on body

3½–5½ft
1–1.7m

RINGED SEAL
Pusa hispida
This small seal mainly inhabits Arctic ice shelves. Pups are born in lairs beneath the ice to protect them from predators.

COMMON SEAL
Phoca vitulina
Also known as the harbor seal, this dainty seal is widespread along temperate coasts. It hauls out onto sandy beaches and sheltered reefs.

3½–4½ft
1.1–1.4m

BAIKAL SEAL
Pusa sibirica
This small, freshwater seal is found in Lake Baikal, Siberia. In winter, it uses its teeth and claws to maintain breathing holes in the ice.

5ft
1.5m

CASPIAN SEAL
Pusa caspica
About half a million of this small species live in the Caspian Sea. Unlike other seals, the male is thought to take only one mate, not fighting off other males.

SKUNKS AND RELATIVES

This small group of cat-sized mammals from the Americas is named for its most distinctive behavior—that of squirting foul-smelling musk at an aggressor. The family name, Mephitidae, comes from the Latin word for "bad smell."

8–12½ in
20–32 cm

PALAWAN STINK BADGER
Mydaus marchei
This bumbling cousin of the American skunks is found only on the Philippine islands of Palawan and Calamian. It eats mainly invertebrates.

12½–19½ in
32–49 cm

HUMBOLDT'S HOG-NOSED SKUNK
Conepatus humboldtii
A native of southern Chile and Argentina, this small skunk detects underground invertebrate prey by scent and digs it up.

10–14 in
25–35 cm

HOODED SKUNK
Mephitis macroura
This widespread Central American skunk occupies a range of habitats, feeding on fruits, eggs, and small animals.

EASTERN SPOTTED SKUNK
Spilogale putorius
A relatively small, weasel-like skunk from the eastern USA, this species is more agile than other skunks and climbs well.

9–13 in
23–33 cm

white stripe warns predators of foul secretions

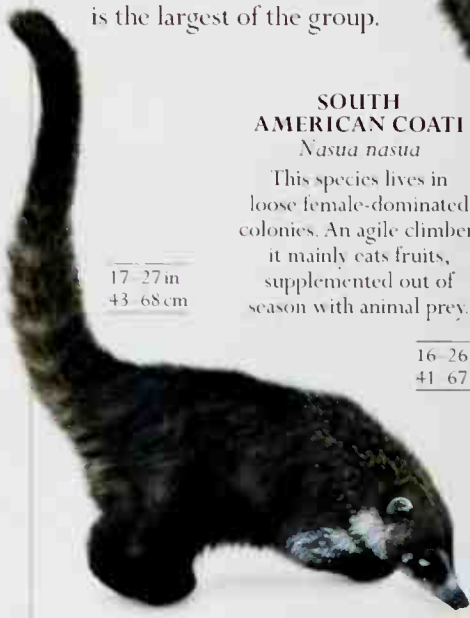
long hairs on tail and back rise when animal is alarmed

STRIPED SKUNK
Mephitis mephitis
This nocturnal omnivore ranges from Canada to Mexico. Its northern populations hibernate in winter.

9–16 in
23–40 cm

RACCOONS AND RELATIVES

Raccoons, kinkajous, and olingos of the family Procyonidae are nimble New World carnivores. Most species are omnivorous and eat mainly plant material (especially fruits) and also insects, snails, small birds, and mammals. The raccoon is the largest of the group.

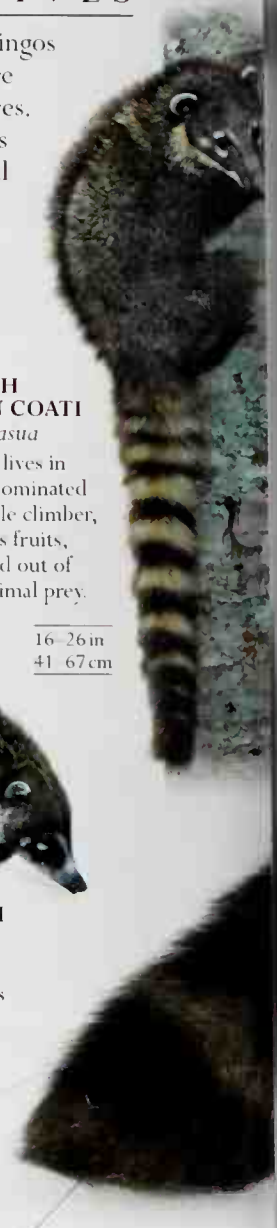


17–27 in
43–68 cm

SOUTH AMERICAN COATI
Nasua nasua
This species lives in loose female-dominated colonies. An agile climber, it mainly eats fruits, supplemented out of season with animal prey.

16–26 in
41–67 cm

WHITE-NOSED COATI
Nasua narica
This social Central American omnivore spends the day foraging at ground level. It climbs well, and often sleeps in trees.



tail has faint dark rings

RED PANDA

This tree-dwelling, herbivorous mammal is usually placed in its own family, the Ailuridae, though some zoologists classify it with the raccoons, others place it in a group with the giant panda.

LESSER PANDA
Ailurus fulgens
Also known as the red panda, this raccoonlike mammal inhabits temperate forest in the Himalayas. It eats fruit and some animal matter.

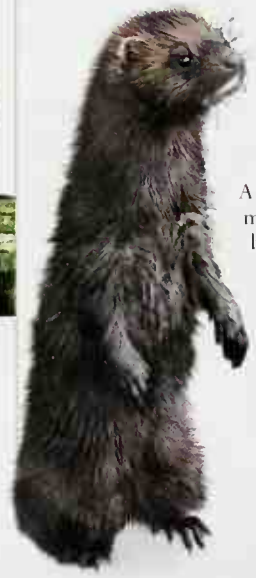
20–29 in
50–73 cm

WEASELS AND RELATIVES

Members of the family Mustelidae occur throughout Eurasia, Africa, and the Americas. They are characterized by a sinuous body and short legs, although the badgers and wolverines are more robust. Most are active predators and good swimmers.

8–14 in
20–36 cm

EUROPEAN MINK
Mustela lutreola
A semiaquatic predator, this species was once widespread in central and western Europe, but is now much less common than the introduced American mink.



12–17 in
30–43 cm

AMERICAN MINK
Neovison vison
A fierce and stealthy predator, this mink is also a skilled swimmer. It has been introduced worldwide by fur farmers.

tail has conspicuous black tip

OLINGO
Bassaricyon gabbii
Olingos are shy, nocturnal fruit-eaters. This is one of the three species found in the forests of Central America and northern South America.

14–19 in
35–49 cm

KINKAJOU
Potos flavus
A nocturnal tree-dweller from Central and South America, the kinkajou uses its long tongue to pluck fruits and collect honey from bee nests.

16–30 in
41–76 cm

prehensile tail

long fur is grizzled

RACCOON
Procyon lotor
This adaptable opportunist favors wooded and scrubby habitats across North America, but often thrives in towns by scavenging human refuse.

black "mask" covers small eyes

17½–24 in
44–62 cm

12–14½ in
30–37 cm

RINGTAIL
Bassariscus astutus
An agile omnivore from Central America, this species forages by night for fruits and small animal prey, pausing often to scent-mark territory.

8–18 in
20–46 cm

EUROPEAN POLECAT
Mustela putorius
This lively nocturnal species, found in forests and meadows of central and western Europe, is the ancestor of the domestic ferret.

pointed muzzle

6½–13½ in
17–32 cm

STOAT
Mustela erminea
This lithe and ferocious little predator is found throughout much of the Northern Hemisphere. Its most northerly populations turn white in winter.

BLACK-FOOTED FERRET
Mustela nigripes
Extinct in the wild in the late 20th century, this slender burrowing ferret has been reintroduced to reserves in the midwestern USA.

14–20 in
35–51 cm

4"–10 in
11–26 cm

slender, elongated neck

LEAST WEASEL
Mustela nivalis
The smallest carnivore, yet a fierce and highly successful predator, this weasel specializes in hunting mice.

9–10 in
23–26 cm

LONG-TAILED WEASEL
Mustela frenata
A widespread species of the Americas, this weasel hunts mice and voles. Northern individuals turn white in winter.

» WEASELS AND RELATIVES

22–28 in
55–70 cm

HOG BADGER
Arctonyx collaris
Native to Southeast Asia, this badger uses its elongated snout to root around for edible morsels on forest floors.

four white stripes from head to tail

AMERICAN BADGER
Taxidea taxus
This burrowing animal inhabits grassland and woodland throughout central North America. It eats a huge variety of plants and animals.

16½–28 in
42–72 cm

white stripe from nose, down the back to the rump

22–35 in
56–90 cm

EURASIAN BADGER
Meles meles
This stocky badger inhabits wooded terrain across much of Europe and Asia. It lives communally in extensive burrow systems called setts.

29–38 in
74–96 cm

HONEY BADGER
Mellivora capensis
An exceptionally feisty animal, this species lives in western and southern Asia, and Africa. It raids beehives for honey, but also eats termites, scorpions, and porcupines.

18½–22 in
47–55 cm

GREATER GRISON
Galictis vittata
This adaptable omnivorous weasel with badgerlike markings is found in tropical forest and grassland in Central and South America.

26–41 in
65–105 cm

WOLVERINE
Gulo gulo
This large mustelid is widespread in North America and Eurasia. Its voracious feeding habits have earned it its other name, "glutton."

SABLE
Martes zibellina
This fierce predator from the forests of Siberia, China, and Japan is hunted in turn by humans for its luxuriantly soft, silky fur.

14–22 in
35–56 cm

flattened tapering tail

dense, dark brown coat

18–26 in
45–65 cm

FISHER
Martes pennanti
Found in dense North American forests, this large marten rarely eats fish, and is one of the few predators to tackle porcupines.

18–23 in
45–58 cm

EUROPEAN PINE MARTEN
Martes martes
Present in forests throughout much of Europe, this lively hunter is seldom seen, as it is nocturnal and wary of humans.

16–21½ in
40–54 cm

BEECH MARTEN
Martes foina
Widespread in Eurasia, this marten emerges from a rock crevice or hollow log at dusk in search of small mammals, birds, and seasonal fruits.

AFRICAN ZORILLA
Ictonyx striatus

A striped polecat, this African species hunts a range of prey by night. It rests by day in hollow logs or burrows.

13–15 in
28–38 cm

long front claws to dig up buried insects

dorsal stripe runs to the tail

9½–13 lb
24–33 cm

AFRICAN STRIPED WEASEL
Poecilogale albinucha

Found in central and southern Africa, this species lives in self-dug burrows. It emerges at night to hunt for smaller animals, especially rodents, which it tracks by scent.

29–35 in
73–88 cm

3½–4½ ft
1–1.3 m

GIANT OTTER
Pteronura brasiliensis

This South American predator needs 7 lb (3 kg) of fish a day. Fewer than 5,000 individuals of this endangered species remain.

AFRICAN CLAWLESS OTTER
Aonyx capensis

Found alongside water in forests and wetland throughout much of sub-Saharan Africa, this large otter eats mainly crabs, frogs, and fish.

14–18½ in
36–47 cm

grayish white flecks on face and throat

ASIAN SMALL-CLAWED OTTER
Aonyx cinerea

The world's smallest otter, this species lives in wetlands in India and Southeast Asia. Its survival is threatened by habitat loss and pollution.

short, blunt claws

20–35 in
50–90 cm

21–29 in
53–73 cm

2½–4 ft
75–120 cm

EURASIAN RIVER OTTER
Lutra lutra

Eurasian otters thrive in both river and coastal habitats, as long as they have access to freshwater for drinking and washing.

NORTH AMERICAN RIVER OTTER
Lontra canadensis

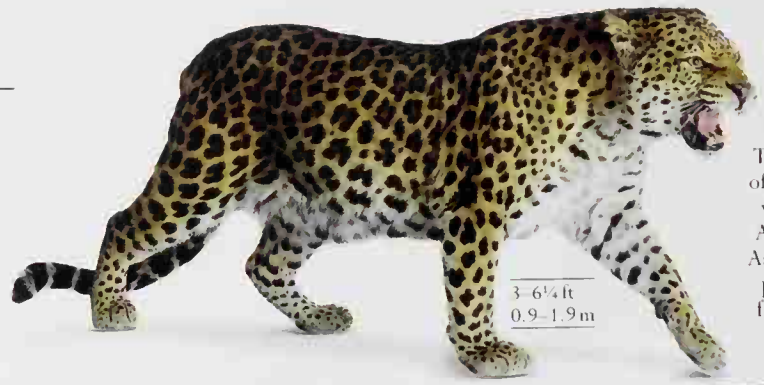
Widespread in North America, this species inhabits well-vegetated rivers and lake shores. It eats mainly fish and crayfish, but also hunts small land animals.

SEA OTTER
Enhydra lutris

The sea otter hunts fish and shellfish in the cool North Pacific, relying on its incredibly dense fur to keep warm.

CATS

Members of the cat family, or Felidae, are among the most specialized of meat-eaters, and many species consume no vegetable material at all. As a group, cats are supremely athletic, with supple, muscular bodies that are well adapted to running, climbing, leaping, and swimming. Their short jaws contain sharp teeth adapted for stabbing (canines) and slicing (carnassials). They have retractile claws.



3–6¼ ft
0.9–1.9 m

LEOPARD
Panthera pardus
This most adaptable of the big cats occurs widely throughout Africa and southern Asia. It often hides its prey in trees, away from other hunters.

26–42 in/67–107 cm

CLOUDED LEOPARD
Neofelis nebulosa
A large nocturnal southeast Asian forest cat with cloud-shaped markings, this species is declining due to hunting and habitat loss.

BLACK LEOPARD
Panthera pardus
Melanistic black coloration is not uncommon among leopards. Also known as black panthers, they are found mainly in dense, moist forests in southeast Asia.

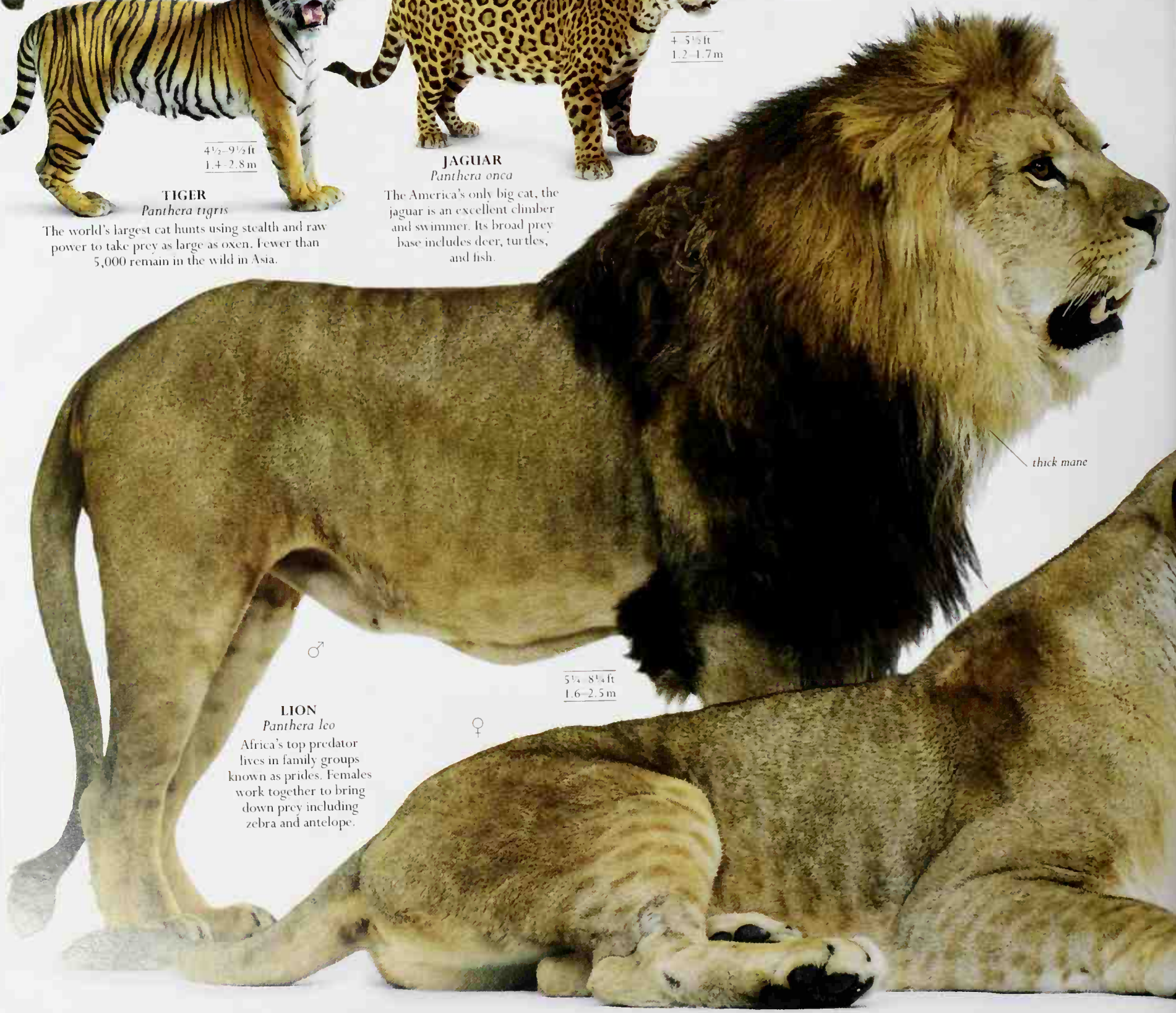
3–6¼ ft
92–190 cm

4½–9½ ft
1.4–2.8 m

TIGER
Panthera tigris
The world's largest cat hunts using stealth and raw power to take prey as large as oxen. Fewer than 5,000 remain in the wild in Asia.

4–5½ ft
1.2–1.7 m

JAGUAR
Panthera onca
The America's only big cat, the jaguar is an excellent climber and swimmer. Its broad prey base includes deer, turtles, and fish.



5¼–8¼ ft
1.6–2.5 m

LION
Panthera leo
Africa's top predator lives in family groups known as prides. Females work together to bring down prey including zebra and antelope.

4¼–4ft
86–125cm

SNOW LEOPARD
Uncia uncia

At home in the remote high mountains of central Asia, the snow leopard lives alone and hunts wild sheep and goats, deer, and marmots.

32–43in
80–110cm

EURASIAN LYNX
Lynx lynx

This large lynx is big enough to tackle small deer. One kill will feed an individual for about a week.

27–32in
68–82cm

IBERIAN LYNX
Lynx pardinus

Now being bred in captivity, this lynx is probably the world's most endangered cat, with fewer than 150 remaining wild in Spain.

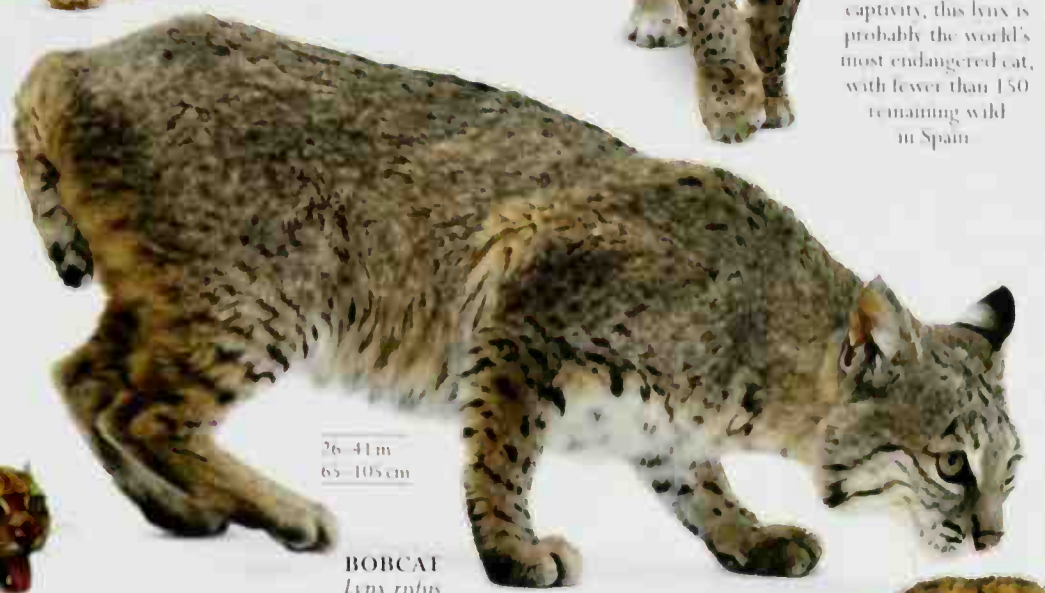
large tufted ears

24–42in
61–106cm

CARACAL
Caracal caracal

Nocturnal hunters of medium-sized prey, such as hyraxes and small antelope, caracals occupy dry scrublands in Africa and southwestern Asia.

short tail



26–41in
65–105cm

BOBCAT
Lynx rufus

This adaptable stalk-and-pounce predator is named for its short "bob" tail. It occurs throughout North America and hunts mainly rabbits.

21–26in
53–67cm

BAY CAT
Catopuma badia

Fewer than eight of this little-known forest cat, found only on the island of Borneo, have been caught since 1928.

32–42in
80–106cm

CANADIAN LYNX
Lynx canadensis

The Canadian lynx inhabits dense forests and tundra. Its numbers fluctuate with the availability of its preferred prey, the snowshoe hare.

small head with high-set eyes

long tail with balancer

29–41in
73–105cm

ASIAN GOLDEN CAT
Catopuma temminckii

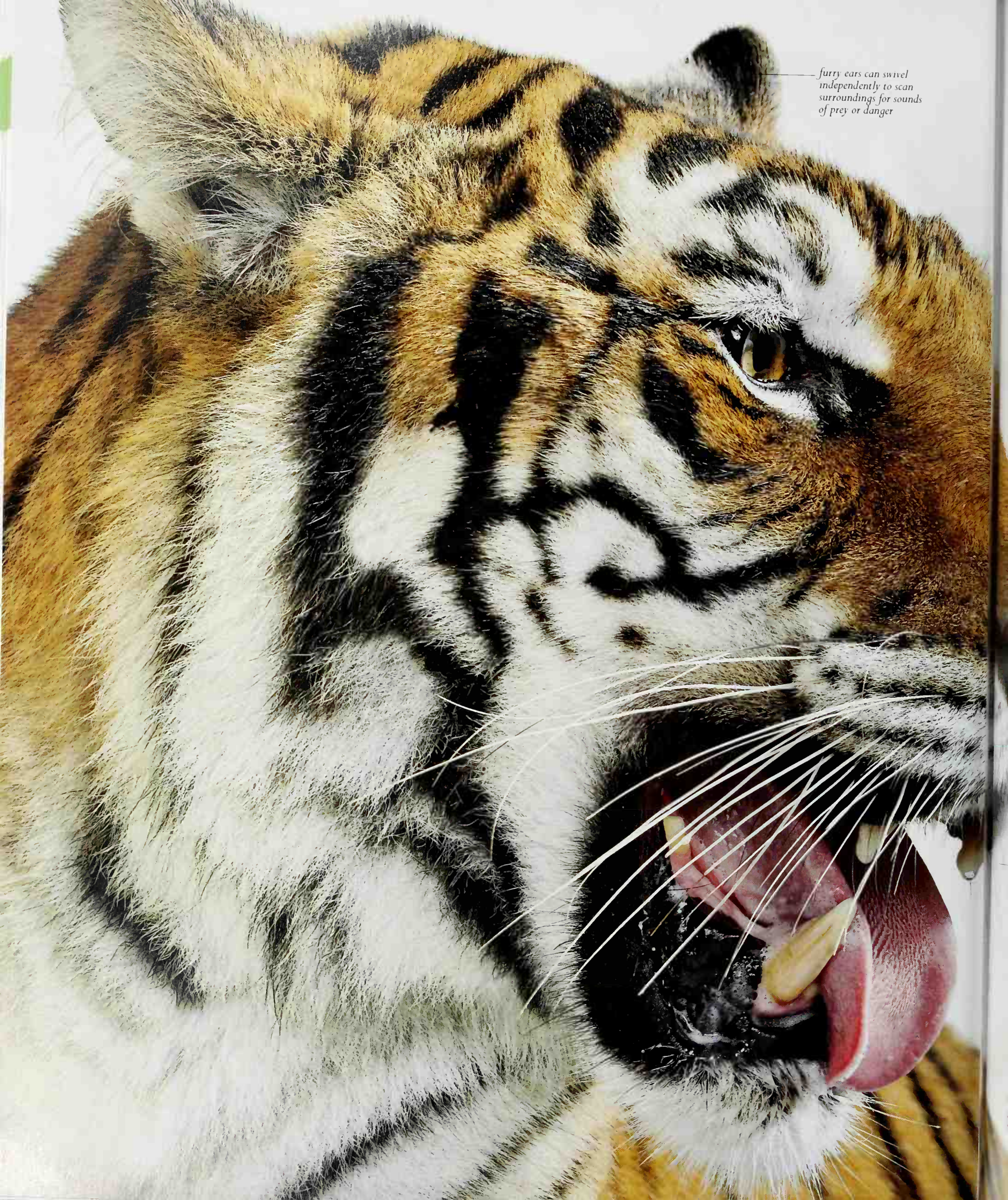
This large golden brown, occasionally spotty, cat inhabits forested parts of Southeast Asia. Pairs cooperate to hunt and rear young.

CHEETAH
Acinonyx jubatus

The fastest animal on four legs, reaching 64 mph (104 kph), the cheetah uses speed to catch antelope on the African savanna.

4–5ft/1.2–1.5m

»


furry ears can swivel independently to scan surroundings for sounds of prey or danger

TIGER
Panthera tigris

The largest and most striking of the big cats, the tiger is a powerful predator with almost supernatural grace and agility. Its natural range extends from the tropical jungles of Indonesia to the snowy expanses of Siberia, where the largest individuals are found. A full-grown male may weigh anything up to 660 lb (300 kg), but despite this bulk it can leap up to 33 ft (10 m) in a single bound. Adult tigers live alone, except for females with cubs—mothers watch over their cubs for two years or more, while teaching them vital survival skills.

SIZE 4½–9¼ ft (1.4–2.8 m)
HABITAT Forests, swamps, scrub thickets, savanna, and rocky landscapes
DISTRIBUTION India to China, Siberia, the Malay peninsula, and Sumatra
DIET Mainly hooved animals, such as deer and pigs, may also catch smaller mammals and birds

sense of smell is surprisingly poor, although tigers do use scent marks to define their territory

ROUND PUPIL >
Unlike small cats, whose pupils contract to vertical slits, tiger pupils are always round. They expand to provide excellent night vision and contract to pinpricks in bright light.

WHITE EAR FLASH v
The prominent white spot on the back of each ear is thought to aid communication. Cubs following their mother will notice ear movements that may signal danger.

long whiskers allow the tiger to feel its way through dense undergrowth in almost total darkness

FORELIMBS >
The tiger has long legs and large feet, which allow it to run fast, leap large distances, and knock prey as large as oxen to the ground with a single, deadly swipe.

^ STAB AND SLICE
Four long canine teeth deliver the killing bite to a tiger's prey. Blade-edged cheek teeth called carnassials slice through the meat with ease.

retracted claw

nonslip pad

< KILLER IN STRIPES
A fiery orange coat marked with bold black stripes provides superb camouflage as the tiger moves through sun-dappled vegetation. The white tigers seen in zoos are usually bred in captivity and are extremely rare in the wild. Indeed, tigers have been hunted almost to extinction, globally, there are fewer than 8,000 left in the wild.

^ PADDED PAW
Tigers have five toes—four on the sole of the foot and the fifth forming a dew claw. The claws are withdrawn fully into the paw when not in use.

< TAIL END
The long tail is typically held curved just above the ground. The tiger uses it to aid balance when chasing prey or climbing.

14–20 in
35–50 cm

SIAMESE CAT
Felis catus
This elegant and sociable breed originated in Thailand. Siamese kittens are born cream and develop their dark extremities as they grow.

14–20 in
35–50 cm

TABBY CAT
Felis catus
The tabby is not a breed but a coat pattern found in many breeds. It resembles the pattern seen in the ancestral wild cat.

14–20 in
35–50 cm

SPHYNX CAT
Felis catus
Hairless except for a peachy fuzz, sphynx cats were developed in Canada. They are sociable and like to be cuddled because they feel the cold.

14–20 in
35–50 cm

CORNISH REX
Felis catus
This is an unusual breed in which the guard hairs of the fur are missing, leaving only downy underfur.

14–20 in
35–50 cm

MANX CAT
Felis catus
Short-tailed cats appeared naturally on the Isle of Man over 300 years ago. The trait spread rapidly in the small island population.

16–26 in
40–66 cm

EUROPEAN WILD CAT
Felis silvestris silvestris
This elusive but ferocious predator is declining due to persecution, habitat loss, and interbreeding with feral domestic cats.

16–20 in
40–50 cm

INDIAN DESERT CAT
Felis silvestris ornata
Also known as the Asian steppe wildcat, this subspecies is distinguished from its European relatives by its smaller size and spotted golden coat.

14–20 in
35–50 cm

PERSIAN CAT
Felis catus
A long-established and popular breed, this domestic cat is characterized by long hair and a short muzzle.

yellowish gray to reddish brown fur

24–34 in
61–85 cm

JUNGLE CAT
Felis chaus
A large and relatively common wild cat occuring from Egypt to Indonesia, the jungle cat prefers grassland and swampy habitats.

10–12 in
25–31 cm

SAND CAT
Felis margarita
A small desert specialist found in North Africa, Arabia, and Kazakhstan, the sand cat hunts gerbils and other nocturnal rodents.

14–20 in
36–52 cm

BLACK-FOOTED CAT
Felis nigripes
An opportunistic solitary hunter, the black-footed cat is threatened by persecution and habitat loss in its native southern Africa.

18–26 in
46–65 cm

PALLAS'S CAT
Felis manul
This short-legged cat lives in the stony deserts of central Asia. Its coat provides useful camouflage when stalking pikas, gerbils, and grouse.

23–36 in
58–92 cm

SERVAL
Leptailurus serval
Found in grassland habitats throughout much of Africa, this distinctive-looking cat is an agile predator of small mammals.

18–24 in
45–62 cm

MARBLED CAT
Pardofelis marmorata
A rare forest species adapted to life in the trees, the southeast Asian marbled cat climbs well and preys mainly on birds.

pointed ears

14–19 in
35–48 cm

RUSTY-SPOTTED CAT
Prionailurus rubiginosus
This lively cat from India and Sri Lanka stalks most of its prey on the ground, but is also an excellent climber.

LEOPARD CAT
Prionailurus bengalensis
This variable species has a huge range. Russian leopard cats are up to three times heavier than those in the forests of Indonesia.

18–30 in
45–75 cm

22½–45 in
57–115 cm

FISHING CAT
Prionailurus viverrinus
A large cat with a patchy distribution in southern and southeast Asia, the endangered fishing cat also eats waterfowl and land animals.

18–20½ in
45–52 cm

FLAT-HEADED CAT
Prionailurus planiceps
This unusual water-loving cat from southeast Asia hunts mainly fish and crustaceans, which it finds by dipping its head or groping with its paws.

nocturnal eyes

»

sandy colored coat

round head with erect ears

large canine teeth for killing prey

2¾–5 ft
0.9–1.6 m

long hind legs for exceptional sprinting and leaping power

PUMA
Puma concolor
Also known as cougar, panther, and mountain lion, the puma occupies rugged terrain across a vast range from Canada to Argentina.

19½–33 in
49–83 cm

JAGUARUNDI
Puma yagouaroundi
One of the largest and most widespread South American cats, the jaguarundi hunts small mammals by day in diverse habitats.

HYENAS AND AARDWOLF

The small family of Hyaenidae contains three species of scavenging hyena and the aardwolf, which specializes in eating insects. Hyenas are characterized by a stocky, doglike body with short hind legs and powerful bone-crushing jaws. They are highly intelligent and live in family groups, called clans.

AARDWOLF
Proteles cristata
This dainty, weak-jawed cousin of the hyenas eats only insects. It lives in East and southern Africa in the dry grassland favored by termites.

22–31 in
55–80 cm

powerful neck and forequarters

3–5½ ft
1–1.7 m

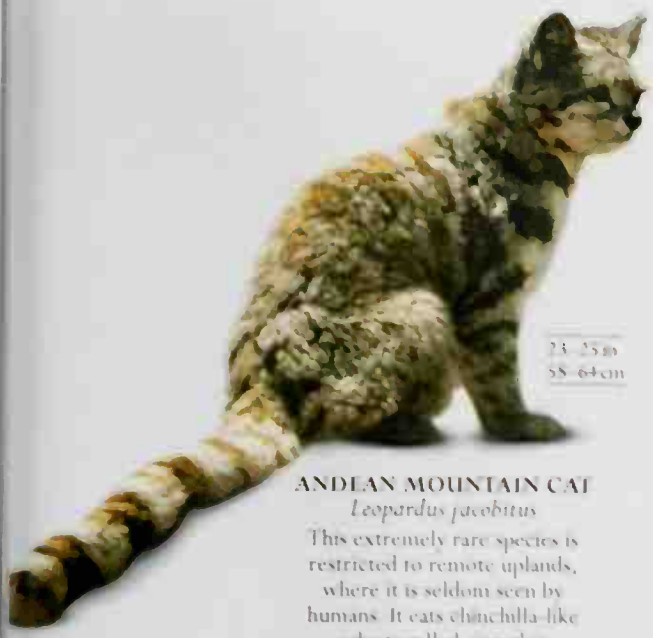
SPOTTED HYENA
Crocuta crocuta
This efficient scavenger is also a proficient hunter of ungulates. It lives in unforested areas of sub-Saharan Africa.

3¼–4 ft
1–1.2 m

STRIPED HYENA
Hyaena hyaena
The small striped hyena is found in open country from North Africa to India. It eats a mixed diet of scavenged meat, small prey animals, and fruit.

3½–4½ ft
1.1–1.4 m

BROWN HYENA
Hyaena brunnea
This social southern African scavenger survives desert conditions by foraging at night and supplementing its diet with watery fruits.



23–25 in
58–64 cm

ANDEAN MOUNTAIN CAT
Leopardus jacobitus
This extremely rare species is restricted to remote uplands, where it is seldom seen by humans. It eats chinchilla-like rodents called viscachas.

spotted coat varies from gray to golden

17–35 in
43–88 cm

GEOFFROY'S CAT
Leopardus geoffroyi
An adaptable hunter of small mammals, fish, and birds, Geoffroy's cat stalks grasslands, forests, and wetlands from Bolivia to southern Argentina.

COLOCOLO
Leopardus colocolo
Highly adaptable, the mainly nocturnal colocolo is found in a wide variety of habitats in South America, from forest to grassland and swamp.

16½–31 in
42–79 cm

15½–22 in
39–55 cm

ONCILLA
Leopardus tigrinus
This spotted forest dweller is widespread from Costa Rica to Argentina, where it hunts rodents, opossums, and birds. It is solitary and nocturnal.

22–39 in
55–100 cm

OCELOT
Leopardus pardalis
Ocelots occupy forested parts of Central and South America. They hunt nocturnally, targeting rodents and other prey on land and in water.

17–31 in
43–79 cm

large eyes adapted to nocturnal lifestyle

MARGAY
Leopardus wiedii
Seldom seen because of its rarity and preference for dense forest cover, the margay is found from Mexico to northern South America.

lithe body adapted for climbing

strong claws are hidden within fleshy sheaths

MALAGASY CARNIVORES

The large island of Madagascar has been separated from other land masses for about 100 million years, allowing its resident mammals to evolve independently. Its native carnivores are now classified in their own family, the Eupleridae. They are very varied in appearance, having diversified to fill the niches occupied elsewhere by predators such as cats, weasels, and mongooses.

stocky body

16–18 in
40–45 cm

MALAGASY FANALOKA
Fossa fossana
A small civetlike animal, the fanaloka inhabits Madagascar's wet forests. It hunts invertebrate prey on land and in water.

23½–32 in
60–80 cm

FOSSA
Cryptoprocta ferox
The catlike fossa is the largest Madagascan carnivore. It hunts mainly lemurs, but it will eat almost any small animal it can catch.

12–15 in
30–38 cm

fatlike pygmy mouse

18–20 in
45–50 cm

FALANOUC
Eupleres goudotii
A ground-dwelling, nocturnal forest animal, the falanouc is an adept digger. It uses its large feet to unearth invertebrate prey.

MALAGASY RING-TAILED VONTSIRA
Galidia elegans
The Madagascan equivalent of mongooses, vontsiras are active forest animals. They feed opportunistically on most plant and animal foods.

V DEMOLITION EXPERT
This tough scavenger can reduce a carcass to nothing in minutes. It will attempt to bolt great chunks of meat before other scavengers arrive. Then, if time allows, they dismember the remains and stash them nearby. Often, all that is left of a herbivore, such as an antelope, is the green stomach contents.

crest of long hairs along the back lies flat when the animal is relaxed

shorter hind legs add to the front-heavy, skulking appearance

SIZE 3¼–4 ft (1–1.2 m)
HABITAT Open country, savanna grassland, and scrub to semidesert
DISTRIBUTION North and East Africa, Middle East to East India
DIET Mainly carrion

STRIPED HYENA
Hyaena hyaena

Maligned in folklore as skulking, cowardly scavengers, most hyenas are also adept hunters in their own right. The striped hyena is less bold and social than its spotted cousin, and, in Africa at least, individuals tend to live a solitary life except when breeding. Elsewhere, such as in Israel and India, striped hyenas more often live in family groups, which are dominated by a single adult female. Carrion forms the bulk of the striped hyena's diet, but it is also partial to fruit, especially melons, which provide valuable water. Striped hyenas are unpopular with farmers, who fear attacks on livestock and damage to crops, but these animals increasingly need conservation, with perhaps fewer than 10,000 remaining in the wild.

muscular shoulders and neck allow the hyena to carry or drag its own bodyweight in carrion

large ears follow sound from any direction

v THROAT
The black throat patch seems to have a social function. When two hyenas meet, they sniff one another and often paw at each other's throat—their equivalent of shaking hands.

^ NOSE FOR TROUBLE
Scent is an important sense to hyenas. Individuals often pause in their daily routine to daub scent from a gland under the tail on rocks and tussocks around their home range.

^ MOUTH AND TEETH
The hyena's stout jaws are operated by immensely powerful muscles. The large cheek teeth (molars and premolars) are easily capable of crushing bones.

< FUR
The striped hyena is smaller than the spotted or brown hyenas, and is distinguished by black stripes on its legs and flanks. The pattern aids camouflage in its dusty habitat.

< ^ LEGS AND FEET
The claws resemble those of dogs rather than cats—they are short and strong but not particularly sharp, and cannot be retracted into the paw. The front legs are notably longer than the hind legs.

MONGOOSES

Mongooses are small, slender-bodied, mostly ground-dwelling carnivores in the family Herpestidae. They live in warm temperate to tropical parts of Africa and Eurasia. Some species live in complex social groups. Mongooses may be the nearest surviving relatives of the first carnivores.

YELLOW MONGOOSE
Cynictis penicillata
Inhabiting dry savanna in southern Africa, this mongoose lives in groups led by a dominant male, but forages independently.

WHITE-TAILED MONGOOSE
Ichneumia albicauda
Found in dry habitats in Africa and the southern part of the Arabian Peninsula, this large insect-eater also feeds on vertebrates and ripe berries.

SLENDER MONGOOSE
Galerella sanguinea
A widespread species in Africa, the slender mongoose generally lives alone. It is active by day and busiest just before dusk.

12½–13½ in
32–34 cm

MEERKAT
Suricata suricatta
This species lives in groups in semidesert habitats. All members help babysit, maintain the burrow, and take turns standing sentry while others forage.

COMMON DWARF MONGOOSE
Helogale parvula
This small, energetic carnivore forages in packs in African grassland, woodland, and brush country. It eats large invertebrates, such as crickets and scorpions.

COMMON CUSIMANSE
Crossarchus obscurus
This forest-dwelling animal from West Africa lives and hunts in nomadic troops. It is said to make an excellent pet.

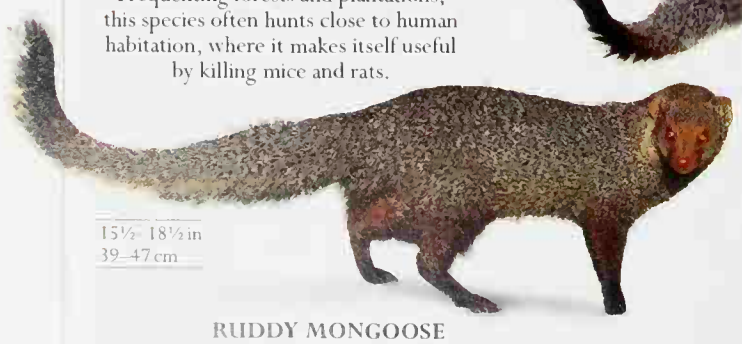
BANDED MONGOOSE
Mungos mungo
Found in troops in sub-Saharan woodland, this mongoose lives in dens, often excavated in termite mounds. Group members are led, but not dominated, by older females.

EGYPTIAN MONGOOSE
Herpestes ichneumon
Not restricted to Egypt, this grizzled gray mongoose occurs in open grassy habitats from Spain to South Africa.

coat marked with broken bands

INDIAN GREY MONGOOSE
Herpestes edwardsi
Frequenting forests and plantations, this species often hunts close to human habitation, where it makes itself useful by killing mice and rats.

INDIAN BROWN MONGOOSE
Herpestes fuscus
This uncommon species occupies the jungles of southern India and Sri Lanka. Like other mongooses, it can kill snakes, but prefers easier prey.



RUDDY MONGOOSE
Herpestes smithii
This little-known Indian forest-dweller hunts birds, reptiles, and smaller mammals. Its tail is sometimes longer than its body.

slender tail

AFRICAN PALM CIVET

The secretive and nocturnal African palm civet is the sole member of the Nandiniidae, which is thought to have split from civet and catlike ancestors between 36 and 54 million years ago.

14½–25 in
37–63 cm

AFRICAN PALM CIVET
Nandinia binotata
This is a very common but shy tree-dwelling species from central Africa. Although an omnivore, it eats mostly fruits.

CIVETS, GENETS, AND LINSANGS

With most species possessing boldly patterned coats, these attractive animals resemble long-tailed cats, but are less specialized meat-eaters. When threatened, these shy and nocturnal animals of the family Viverridae squirt a jet of foul-smelling fluid from stink glands near the base of the tail.

24–38 in
61–97 cm

BINTURONG
Arctictis binturong
A prehensile tail helps this Southeast Asian species move methodically through the forest canopy in search of fruits and small animals.

26–33 in
67–84 cm

AFRICAN CIVET
Civettictis civetta
An opportunistic animal, this large, ground-dwelling omnivore lives alone and marks its territory with a strong musky scent.

20–34 in
51–87 cm

MASKED PALM CIVET
Paguma larvata
This agile, solitary, tree-dwelling native of Indochina eats fruits, insects, and small vertebrates.

16½–28 in
42–70 cm

ASIAN PALM CIVET
Paradoxurus hermaphroditus
With a natural range extending from Pakistan to Indonesia, this fruit-loving civet is considered a pest in palm and banana plantations.

19½–27 in
49–68 cm

SMALL INDIAN CIVET
Viverricula indica
This small ground-dwelling civet inhabits forests, grasslands, and bamboo thickets from Pakistan to China and Indonesia.

18–20½ in
46–52 cm

SMALL-SPOTTED GENET
Genetta genetta
Also called the common genet, this widespread predator of small mammals and birds occupies scrub and forests of Africa and southern Europe.

17–23 in
43–58 cm

CAPE GENET
Genetta tigrina
This genet is found in eastern South Africa and Lesotho. It eats mostly invertebrates, but will tackle prey as large as geese.

21¼–30 in
54–77 cm

ORIENTAL CIVET
Viverra tangalunga
Restricted to the tropical forests of Malaysia, Indonesia, and the Philippines, this nocturnal forager mostly hunts for prey on the ground.

13–18 in
33–45 cm

BANDED LINSANG
Prionodon linsang
Also called the tiger civet, this shy species lives in tree holes in S.E. Asian jungles, hunting rats, squirrels, lizards, and birds.

ODD-TOED UNGULATES

All members of the Perissodactyla are browsers and grazers of plants. They appear to have little in common, but are linked through a series of extinct intermediate forms.

Modern odd-toed ungulate families range from graceful horses to piglike tapirs and massive rhinoceroses. Unlike the Artiodactyla, they have a relatively simple stomach, and rely on bacteria in the cecum, a pocketlike extension of the large intestine, and colon to digest plant cellulose.

In prehistoric times, odd-toed ungulates were among the most important herbivorous mammals, sometimes becoming the dominant herbivores in grassland and forest ecosystems. For a variety of reasons, including competition with even-toed ungulates, most of these species are now known only from the fossil record.

WEIGHT-BEARING TOES

Odd-toed ungulates rest their weight primarily on the third toe of each foot. Indeed, horses have lost the rest of their toes, and the single remaining digit is protected with a well-developed horny hoof. The other two families have retained more toes—three on all four feet in the case of rhinoceroses, and three on the hind legs and four on the front in the case of tapirs.

HORSE POWER

Once distributed across the world, apart from Antarctica and Australasia, extant species in this order are mainly native to Africa and Asia. Only some of the tapir species are found in the Americas, for although the horse family evolved in that region, it had died out by the end of the Pleistocene around 10,000 years ago. The Spanish conquistadors reintroduced the modern domestic horse to the Americas in the 15th century.

Horses have a long history of domestication, especially as transport and pack animals and to provide power for agriculture and forestry. The first equid to be domesticated appears to have been the wild ass, some 7,000 years ago, with horses following about a millennium later. Today there are over 250 horse breeds worldwide.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	PERISSODACTYLA
FAMILIES	3
SPECIES	17

The black rhinoceros is a browser and has a prehensile upper lip, which it uses to grasp twigs and leaves.

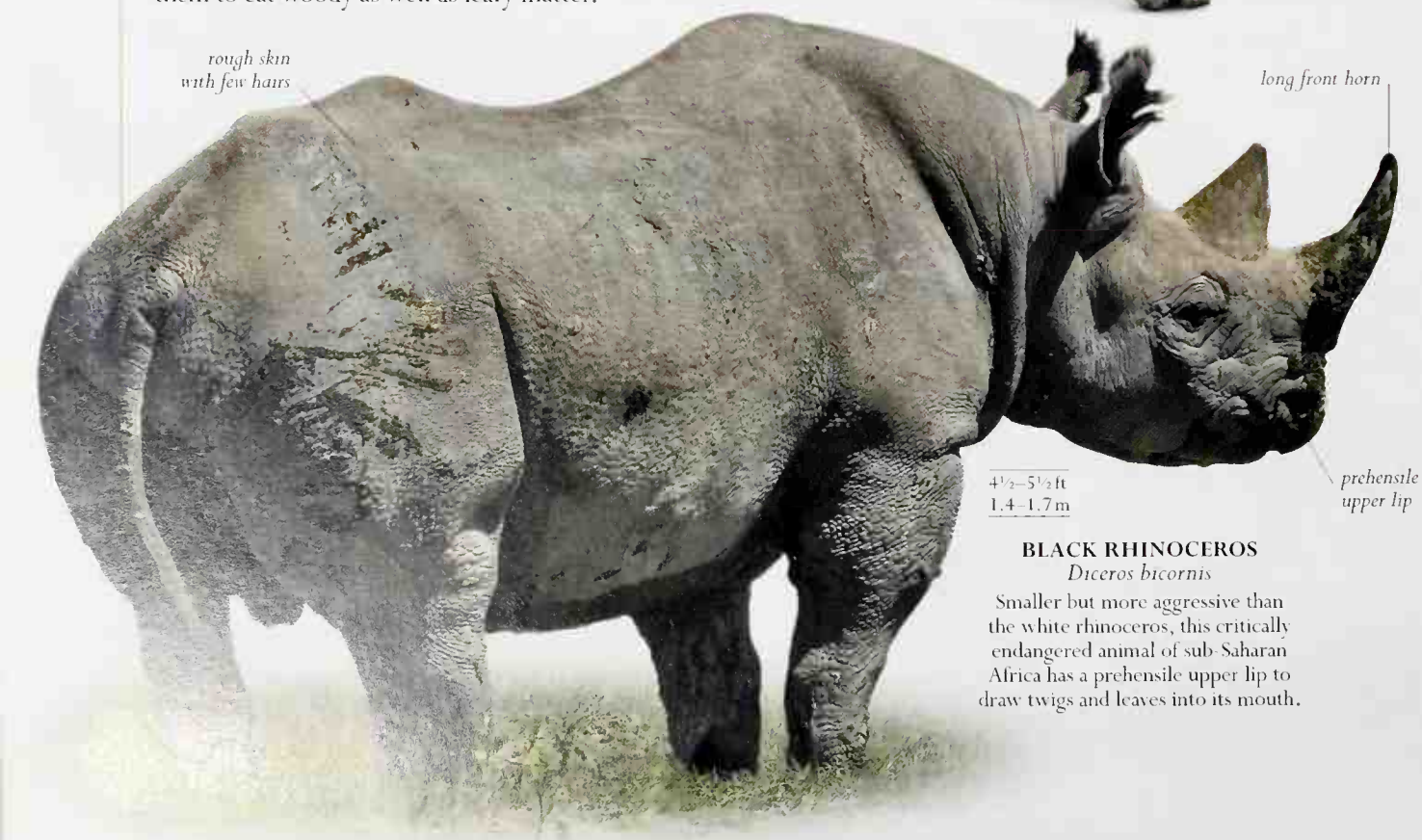
RHINOCEROSES

A huge, barrel-shaped body and a large head bearing one or two horns make the five species of the family Rhinocerotidae unmistakable. While their bulk, horns, and protective skin ensure that they have few natural enemies, these mostly solitary animals are threatened by hunting and the destruction of their habitat. These herbivores can ferment food in their hindgut, which enables them to eat woody as well as leafy matter.

4–5 ft
1.2–1.5 m

SUMATRAN RHINOCEROS
Dicerorhinus sumatrensis

This critically endangered species from Southeast Asian forests is the smallest rhinoceros. The smaller of its two horns is usually a mere stub.



4½–5½ ft
1.4–1.7 m

BLACK RHINOCEROS
Diceros bicornis

Smaller but more aggressive than the white rhinoceros, this critically endangered animal of sub-Saharan Africa has a prehensile upper lip to draw twigs and leaves into its mouth.

TAPIRS

Inhabiting tropical forests, the Tapiridae are found in Southeast Asia, and South and Central America. These large herbivores have a flexible proboscis, a long nose that can grasp foliage overhead. Other distinctive features include oval, white-tipped ears and a protruding rump with a short tail. Young tapirs have a striped and spotted coat. Splayed hooves, with four toes on the front feet and three on the rear, help tapirs walk on soft ground.

MALAYAN TAPIR
Tapirus indicus
This striking, two-toned tapir is the largest and only Asian species. Males and females create overlapping trails around their rain forest territory in Southeast Asia.

8–8½ ft
90–105 cm

2½–3 ft
77–108 cm

SOUTH AMERICAN TAPIR
Tapirus terrestris
Despite its size, this shy tapir is unobtrusive. It moves easily through jungle undergrowth, and is a favored prey of crocodiles.

2½–4 ft
0.8–1.2 m

BAIRD'S TAPIR
Tapirus bairdii
The largest land mammal in South America, it favors waterside habitats in dense jungles and swamps for swimming and wallowing.

30–39 in
75–100 cm

MOUNTAIN TAPIR
Tapirus pinchaque
The smallest of all tapirs, this species inhabits montane cloud forest in the northern Andes. It has a thick, woolly coat and a white lower lip.

5–6½ ft
1.5–1.9 m

WHITE RHINOCEROS
Ceratotherium simum
Found in African savanna, this social species is also the heaviest rhinoceros. "White" is a corruption of "wide"—for the animal's square mouth, adapted for grazing.

5½–6½ ft
1.7–2 m

INDIAN RHINOCEROS
Rhinoceros unicornis
Living in grasslands, forests, and wetlands of India and Nepal, this solitary, single-horned rhinoceros has thick folds of skin around its neck.

4½–5½ ft
1.4–1.7 m

JAVAN RHINOCEROS
Rhinoceros sondaicus
Once widespread in Southeast Asia, this solitary, nocturnal browser is one of the world's rarest animals. Its small horn does not exceed 8 in (20 cm) in length.

»

WHITE RHINOCEROS

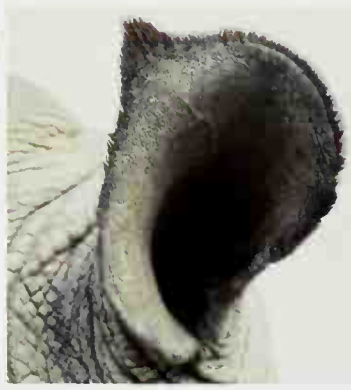
Ceratotherium simum

Despite its unnerving appearance, this giant of the African plains is a mild-tempered vegetarian. The huge horns are used almost entirely in self-defense or for protecting the young. Adult rhinoceroses usually live alone, although they sometimes form loose groups to share feeding areas. Males are territorial and mark their territory with pungent urine and droppings. They will compete for the right to mate with a certain female, but most disputes are solved with a bout of showing off, after which the weaker male backs down. This species has suffered a drastic decline in numbers and range as a result of hunting and habitat loss.

SIZE 5–6¼ ft (1.5–1.9 m)
HABITAT Savanna grassland
DISTRIBUTION Central and South Africa
DIET Grass

∨ NEARSIGHTED
Rhinoceroses are somewhat nearsighted. Having eyes located on the sides of the head gives them a wide field of vision, but limits their ability to see straight ahead.

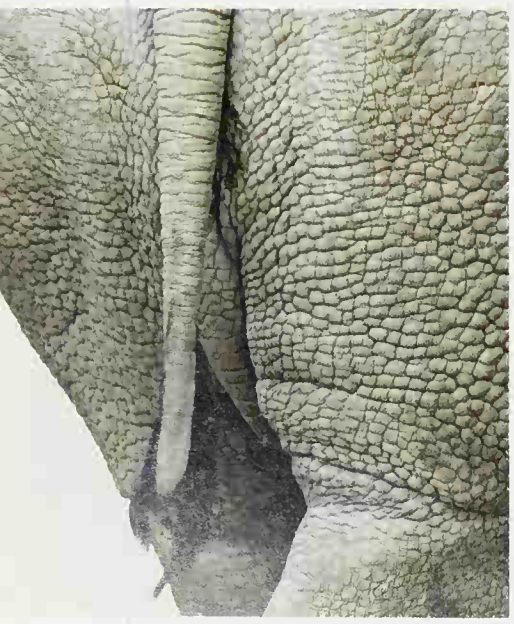
∨ HAIRY EARS
The ears are the hairiest part of a rhinoceros's body. They provide excellent hearing, and swivel to detect sounds from any direction.



WIDE MOUTH >
The white rhinoceros is the largest animal to survive on an exclusive diet of grass. Its wide, straight mouth is shaped for maximum efficiency when cropping short grass.

< HORN OF HAIR
Rhinoceros horn is made of a protein called keratin. The same substance is found in hair and nails — in fact, the rhinoceros's horn is little more than a mass of compacted hair.

the horn of a mature white rhino may grow up to 5 ft (1.5 m) long— and attract poachers



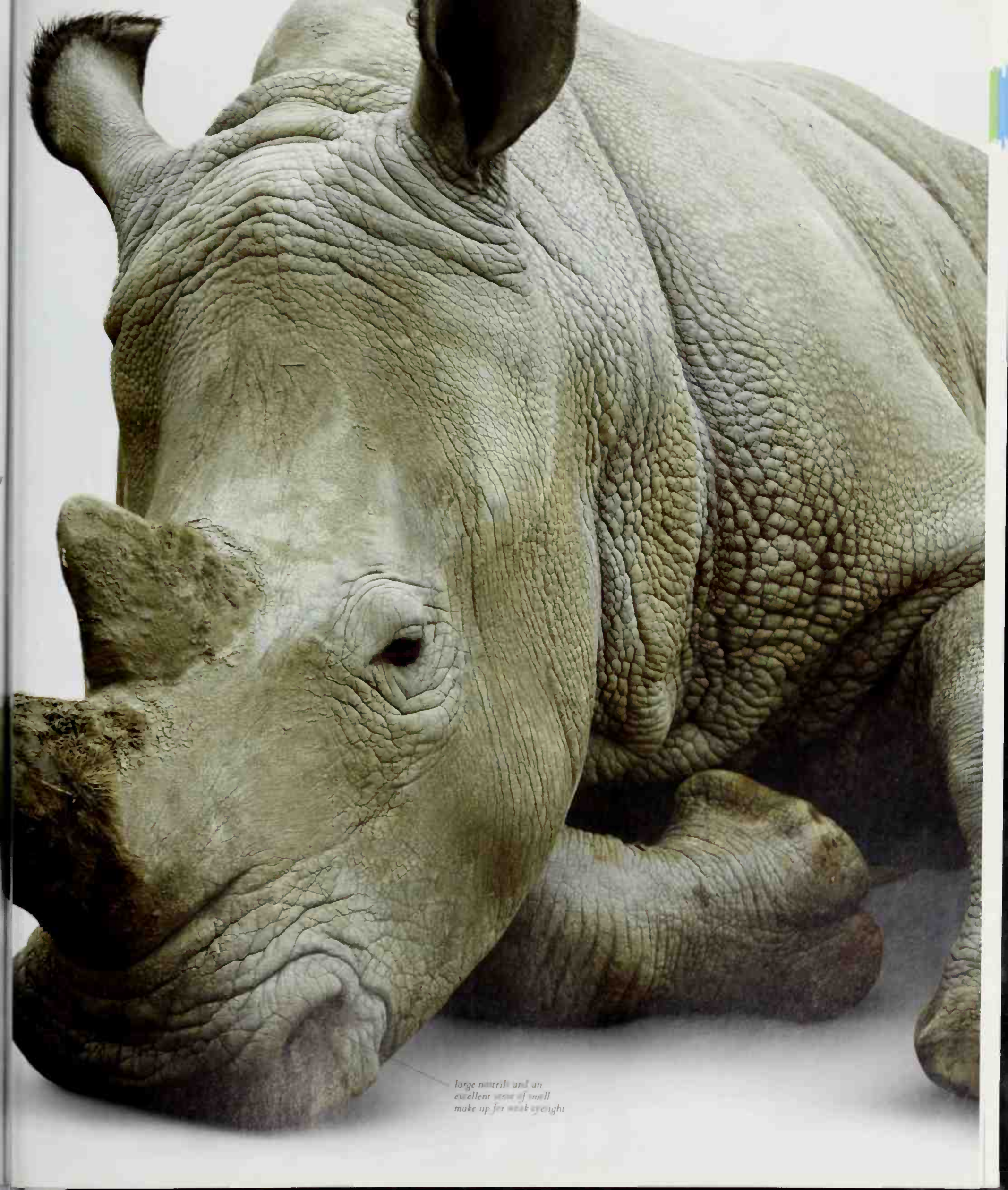
^ TELLING TAIL
The short tail hangs down when the rhinoceros is relaxed and curls up like that of a pig at times of excitement, such as when mating.

< RHINO HIDE
Despite the species' name, the tough, wrinkled skin of the white rhinoceros is gray, not white. Up to ¾ in (2 cm) thick, the skin is made up of layers of collagen, arranged in a crisscross pattern.

< UNDERSIDE OF FOOT
The unusual shape of a rhinoceros's foot makes the animal relatively easy to track. Some experienced trackers can even recognize individual animals from their footprint.

< THREE TOES
Rhinoceroses have three toes on each foot. Most of the weight is borne on the middle toe, with the smaller side toes aiding balance and grip.

> GENTLE GIANT
White rhinoceroses suffer from an undeserved reputation for bad temper. In reality they are peace-loving, even timid, animals. Under normal circumstances they charge only when provoked or confused. The black rhinoceros is much more aggressive.



large nostrils and an
excellent sense of smell
make up for weak eyesight

HORSES AND RELATIVES

Although the Equidae are a large family in the fossil record, just seven species of horse, donkey, and zebra remain. They live in herds, inhabiting open grassland and desert. They have all-round vision and their movable, sensitive ears alert them to predators. These swift animals have slender legs with a single hoofed toe, and their coat is short except for longer hair on the mane and tail.

stiff, striped mane

narrow, intermediate stripes

4¼–4½ ft
1.3–1.4 m

CHAPMAN'S ZEBRA
Equus burchelli antiquorum
This zebra from southern Africa is a subspecies of the plains zebra. It has characteristic shadow stripes on its body that alternate with the black ones.

3¼–4½ ft
1–1.4 m

MOUNTAIN ZEBRA
Equus zebra
Found in southwest Africa, this species lives in dry, rocky, mountainous habitats. It has broad stripes on the hindquarters that contrast with its narrow stripes elsewhere.

4–4½ ft
1.2–1.4 m

GRANT'S ZEBRA
Equus burchelli boehmi
The smallest of the six subspecies of the plains zebra, this mammal has broad, defined stripes. It is a native of the savanna in East Africa.

5–5¼ ft
1.5–1.6 m

GREVY'S ZEBRA
Equus grevyi
The largest wild species in its family, this big-eared zebra from East Africa has narrow, variable stripes on its body and a white belly.

4–4¼ ft
1.2–1.3 m

KHUR
Equus hemionus khur
A fast runner from arid Asian grasslands, this subspecies is now found in the wild only in a sanctuary in Gujarat, India.

dorsal stripe

4–4¼ ft
1.2–1.3 m

KULAN
Equus hemionus kulan
A little larger than most donkeys, this subspecies of the Asiatic wild ass has a black dorsal stripe, edged with white, and a short, black mane.

4–5 ft
1.2–1.5 m

PERSIAN ONAGER
Equus hemionus onager
Extinct in much of its former Asian range and now found only in parts of Iran, this subspecies has a brown dorsal stripe on its back.

4½–5 ft
1.4–1.5 m

KIANG
Equus kiang
The largest wild ass, the kiang inhabits the Tibetan plateau. Its chestnut-colored coat is the darkest of all Asian wild asses, and is woolly in winter.

gray-brown coat

striped legs

4¼–5 ft
1.3–1.5 m

SOMALI WILD ASS
Equus asinus somalicus
The ancestor of the donkey, this wild ass from northeast Africa has a short, gray coat, and striped, zebralike legs.

35–51 in
0.9–1.3 m

DONKEY
Equus asinus asinus
The domesticated form of the African wild ass, this subspecies has a worldwide distribution as a transport and pack animal.

PRZEWALSKI'S HORSE
Equus caballus przewalskii

The last true wild horse, this species often bears faint leg stripes. It once survived only in captivity, but is now being reintroduced into the wild in Mongolia.

4½–4¾ h
1.3–1.4 m

pale muzzle

pale, yellowish brown flanks

brown legs, often with faint stripes

single toe encased in a hoof

3½–4¼ h
1.1–1.3 m

EXMOOR PONY
Equus caballus caballus

This rare, primitive, and hardy pony survives semiwild in Exmoor, England. It is always dun, bay, or brown with black points.

SHIRE HORSE
Equus caballus caballus

A large, powerful horse, bred in England from Dutch stock, this breed is still used in agriculture and forestry for pulling heavy loads.

5½–6¼ h
1.7–1.9 m

distinctive "dished" face

5 h
1.5–1.6 m

ARABIAN HORSE
Equus caballus caballus

A swift desert horse, the Arabian has had a huge influence on the development of the modern racehorse.

5–5½ h
1.5–1.6 m

PAINT HORSE
Equus caballus caballus

This American horse combines a dark coat, ranging from chestnut to black, with variable white areas.

silky mane

variable coat color

4½–5 h
1.3–1.5 m

MULE
Equus asinus x *E. caballus*

Built like a horse but with the paternal donkey's head and long ears, this generally sterile hybrid is a strong pack animal.

HINNY
Equus caballus x *E. asinus*

The offspring of a male horse and a female donkey, the hinny has a donkeylike body and the head, ears, and mane of a horse.

3½–4 h
1–1.3 m

EVEN-TOED UNGULATES

One of two orders of hoofed mammals, the Artiodactyla stand on two or four toes. Most are herbivorous, and have a multichambered, fermenting stomach.

Even-toed ungulates are often described as cloven hoofed. This is because the tip of each toe has its own hoof—a hard, rubbery, sole surrounded by a thick nail. The hoof wears down through use, but grows continually. Only the camelids lack hoofs—although they walk on two toes, the hoof is reduced to a small nail.

CHEWING THE CUD

With long legs and their feet protected with hoofs, even-toed ungulates often range extensively across grassland and forested habitats in search of food. Most families are grazers of grass and herbs or browsers of shoots and leaves. Their digestive system is well adapted to a diet of tough vegetable matter: the stomach has three or four chambers and contains bacteria that digest the cellulose in plant cell walls, releasing the nutrients inside. To help with this, partly digested food (cud) is regurgitated for further chewing, a process known as rumination. Artiodactyls also have large, broad cheek teeth to grind up their tough food, and long intestines. Pigs and peccaries are somewhat different: with a more omnivorous diet, they have two-chambered stomachs and more general-purpose teeth. In some species, the canine teeth are enlarged into tusks for defense, fighting, and rooting for food.

DOMESTICATION

Introduced into Australasia, members of this order are found on every continent except Antarctica. They vary greatly in shape and in size, with shoulder height ranging from 8 in (20 cm) in the mouse-deer to almost 13 ft (4 m) in the giraffe. Many species are hunted in the wild as food by humans, but others have been domesticated and are economically important—cattle, llamas, sheep, and pigs are used for meat, leather, wool, dairy products, and transport. Domestication has led to the development of animal breeds with a distinctive appearance that matches their specific purpose.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	ARTIODACTYLA
FAMILIES	10
SPECIES	240

DEBATE

ONE SPECIES OR SIX?

Taxonomists, scientists who classify living things, are often described as being either "splitters" or "lumpers." In the heyday of zoological exploration of Africa, there was a tendency to split taxa into too many species, many of which were later lumped back together. Giraffes are a good example, with some dozens of described "species" ending up under the single name, *Giraffa camelopardalis*. More recently, however, genetic evidence has begun to suggest that six subspecies of giraffe, recognizable by their different coat patterns, may indeed be separate species, some of them highly endangered.

PECCARIES

Found in the Americas, the Tayassuidae share many features with pigs, such as small eyes and a snout that ends in a cartilaginous disc. But they have a more complex, chambered stomach, and short, straight tusks.

3–3½ lt
90–110 cm

CHACOAN PECCARY
Catagonus wagneri

Found in the Chaco region of central South America, this large peccary was first described from fossils, and was discovered to be a living species only in 1975.

17½–22½ in
44–57 cm

12–20 in
30–50 cm

WHITE-LIPPED PECCARY
Tayassu pecari

Living in large herds in Central and South America, this species is considered dangerous: when threatened, it charges rather than flees.

COLLARED PECCARY
Pecari tajacu

Widespread in the tropical and subtropical Americas, this diurnal pig is extremely social It is considered destructive in agricultural areas because it often raids crops.

PIGS

Unique in their order, the Old World Suidae have four toes, although they walk only on the middle two. They have a simple stomach, unlike the chambered stomach of most of their relatives. Largely omnivorous, they dig with their snout and tusks for food. They have bristly coats and a short tail that ends in a long tassel.

WARTHOG
Phacochoerus africanus
This pig has a warty face and two pairs of tusks. It often feeds on its front knees when grazing, and runs with its tail erect.

26–37 in
65–80 cm

BURU BABIRUSA
Babyrousa babyrussa
Males of this species have remarkable tusks; the upper canines grow upward, pierce the snout, and curve backward. It is native to some Indonesian islands.

25–34 in
64–85 cm

GIANT FOREST HOG
Hylochoerus meinertzhageni
Unlike most pigs, this large, nocturnal wild species from Africa has a thick covering of black and ginger fur.

23½–34 in
60–85 cm

BUSHPIG
Potamochoerus larvatus
Found in African forests and reedbeds, this pig has brown fur and a pale mane, which stands upright when the animal is alarmed.

rounded back

23½–30 in
60–75 cm

RED RIVER HOG
Potamochoerus porcus
This richly colored pig from central Africa has a pair of lumps on its snout, and distinctive white facial markings.

8–10 in
20–25 cm

PYGMY HOG
Sus salvanius
Once spread across India and Nepal, this tiny, dark brown pig with a sharply tapered snout is now critically endangered.

12–26 in
30–65 cm

VISAYAN WARTY PIG
Sus cebifrons
Three pairs of fleshy warts on the face protect this boar against the tusks of rival males while fighting.

28–37 in
71–84 cm

BEARDED PIG
Sus barbatus
Found in the forests of southeast Asia, this pig often moves in herds. It has a whitish "beard" and distinct tail tassels.

narrow mane of longer hair

long snout ends in a large disk of cartilage

23½–43 in
60–110 cm

WILD BOAR
Sus scrofa
Widespread in Eurasia, the bristly wild boar is the main ancestor of domestic pigs. The piglets have stripes along the body for camouflage in dense thickets.

27½–32 in
60–80 cm

PIÉTRAIN PIG
Sus scrofa domesticus
A Belgian domestic breed that produces high-quality, lean meat, this pig has dark spots set within paler blotches on its body.

28–37 in
70–80 cm

MIDDLE WHITE PIG
Sus scrofa domesticus
Reared in England for pork, this pig is an unpigmented domestic breed, characterized by its round form and short, upturned nose.

MUSK DEER

Found mainly in Asian montane forests, the solitary, nocturnal members of the family Moschidae are named for the musk gland of adult males. These small, stocky deer have enlarged upper canines and longer hind limbs that help them climb rough terrain.

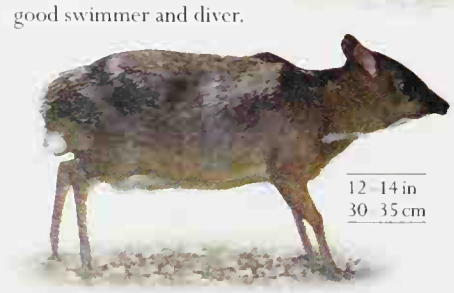
ALPINE MUSK DEER
Moschus chrysogaster
Inhabiting Chinese highland forests, this small deer has long, harelike ears. The male's musk sac produces musk, which is used to mark territory.

CHEVROTAINS AND MOUSE DEER

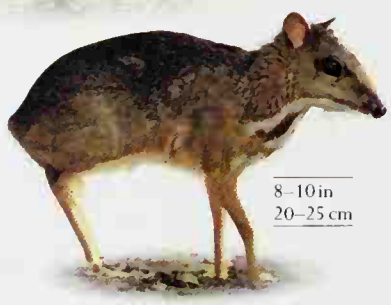
Found in African and Asian tropical forests, the Tragulidae are somewhat similar to small deer, but lack horns or antlers. In males, the enlarged upper canines project from either side of the lower jaw. Like pigs, these deer have four toes on each foot and rather short legs. The stomach is chambered, to ferment and digest tough plant food.

INDIAN SPOTTED CHEVROTAIN
Moschiola meminna
Nocturnal and secretive, this tiny chevrotain from India and Sri Lanka has spots and white stripes on its body.

WATER CHEVROTAIN
Hyemoschus aquaticus
Large and boldly marked with stripes and spots, this mouse deer of West and central African forests is a good swimmer and diver.



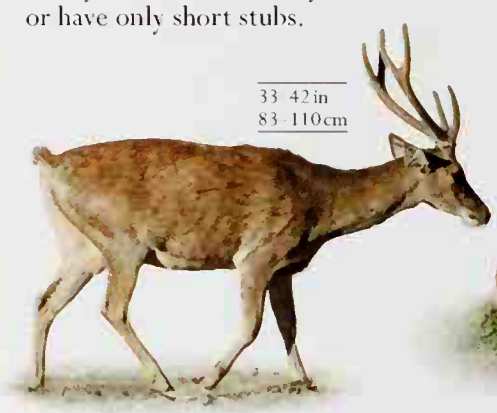
GREATER MOUSE DEER
Tragulus napu
Although quite small, this is the largest Asian mouse deer. Its pointed head has dark stripes running from the large eyes to the black nose.



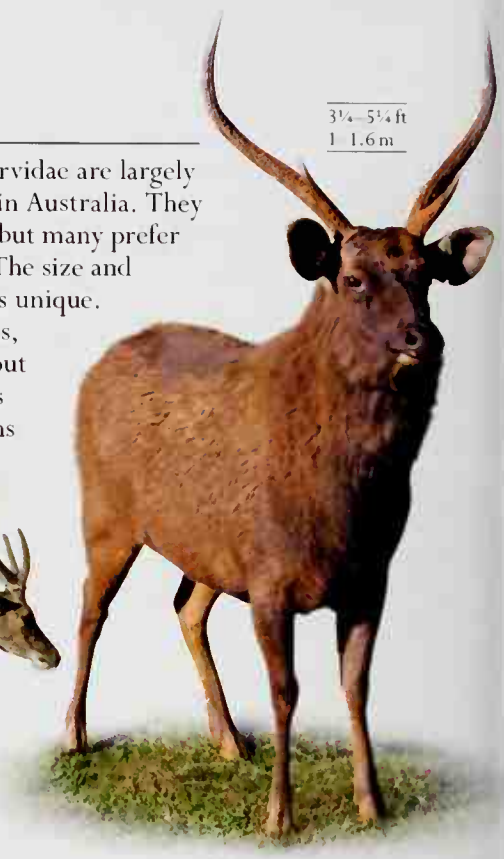
JAVA MOUSE DEER
Tragulus javanicus
This is the world's smallest hoofed mammal. Its relationship with other mouse deer in Southeast Asian forests is poorly understood.

DEER

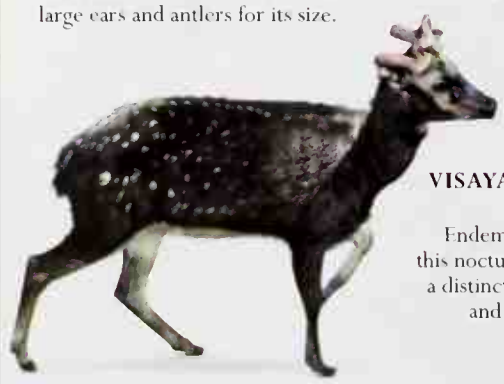
Distributed almost globally, the Cervidae are largely absent from Africa and introduced in Australia. They occupy forested and open habitats, but many prefer the transitional zones in between. The size and form of the antlers of each species is unique. Unlike permanently horned animals, such as antelopes, male deer of all but one species shed and regrow antlers each year; females usually lack horns or have only short stubs.



RUSA DEER
Rusa timorensis
This Indonesian forest deer was introduced into arid Australian bushlands, where it thrives. It has large ears and antlers for its size.



SAMBAR
Rusa unicolor
A large, dark brown deer with a prominent mane, the sambar browses in woodlands throughout southern Asia, up to the Himalayan foothills.



VISAYAN SPOTTED DEER
Rusa alfredi
Endemic to the Philippines, this nocturnal deer has short legs, a distinctive crouching posture, and a dense pattern of pale spots.

REEVES' MUNTJAC
Muntiacus reevesi
Native to eastern Asia, this species was introduced in western Europe. Despite its small size, it damages woodlands by grazing and browsing.

RED MUNTJAC
Muntiacus muntjak
This South Asian deer uses its short, one-branched antlers and elongated upper canines to defend itself against predators and its territory against rivals.

3½–4 ft
1.1–1.2 m

PÈRE DAVID'S DEER
Elaphurus davidianus
Known only from captive populations, this presumed native of China was described in 1865 by a French missionary, Father Armand David.

23½–39 in
60–100 cm

AXIS DEER
Axis axis
Introduced in Australia and North America, this common Indian forest deer has lyre-shaped antlers. It is a favorite prey of tigers.

24–28 in
61–70 cm

HOG DEER
Axis porcinus
Found in Asian forests, this deer is named after its hoglike habit of running head down, going under rather than leaping over obstacles.

palmate antlers

tail white below

30–49 in
75–100 cm

20–28 in
50–70 cm

long, pointed, branched antlers

4–4½ ft
1.2–1.4 m

THEFED DEER
Elaphodus cephalophus
This small deer lives in Asian montane forests. Males of this species have small antlers and short tusks, with a tuft of black hair on the forehead.

FALLOW DEER
Dama dama
Often domesticated as a source of venison, this species is distinguished by its spotted coat and flattened, palmate antlers.

BARASINGHA
Rucervus duvaucelii
This wetland deer from India was introduced in the USA for sport; the multipointed, branched antlers of males are highly prized.

3½–4½ ft
1.1–1.4 m

RED DEER
Cervus elaphus elaphus
From Europe, Turkey, and North Africa, this deer varies across its range in bulk, antler size, and the prominence of its mane.

20–37 in
50–95 cm

SIKA DEER
Cervus nippon
Distinguished by its stout, upright antlers, the sika breeds with red deer, especially when introduced outside its native east Asia.

shaggy fur on neck

reddish brown coat

WAPITI
Cervus elaphus canadensis
Although this North American and Asian subspecies resembles the red deer, genetic analysis suggests it may be a species in its own right.

3½–4½ ft
1.1–1.4 m

MULE DEER
Odocoileus hemionus
This species has a black-tipped tail and forked antlers, which distinguish it from the white-tailed deer that shares its range in western North America.

42–59 in
80–100 cm

grayish brown coat

WHITE-TAILED DEER
Odocoileus virginianus
Found from Canada to Peru, and introduced in Europe and New Zealand, this deer flashes the white underside of its tail when alarmed.

» DEER

26–30 in
65–75 cm

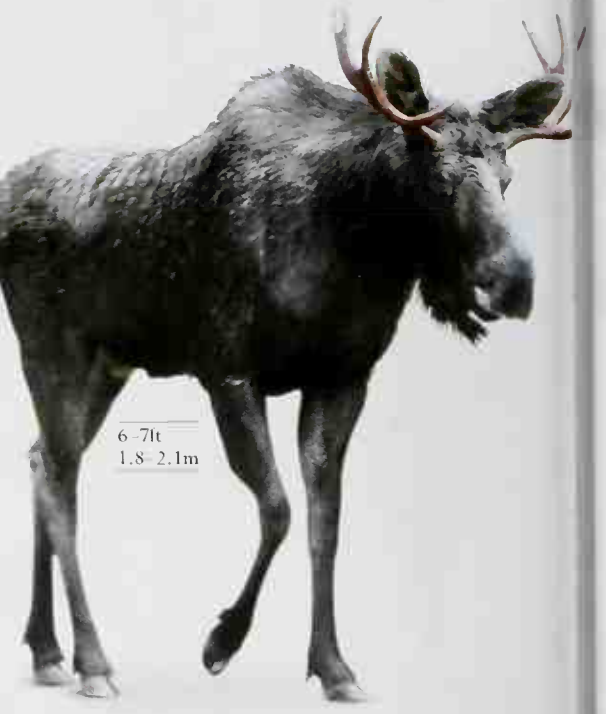
EUROPEAN ROE DEER
Capreolus capreolus
A small European scrub and forest deer, its fur is reddish brown in summer, becoming darker, sometimes almost black, in winter.

REINDEER
Rangifer tarandus
The footpads of this Arctic deer shrink in winter, exposing the hoof rim and enabling it to dig through snow to reach food.

32–59 in
80–150 cm

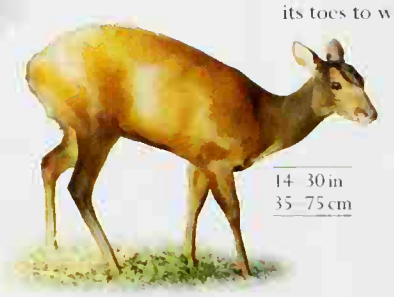
3¼–4 ft
1–1.2 m

MARSH DEER
Blastocerus dichotomus
Adapted to wetland habitats, the marsh deer is the largest South American deer. It swims well and has membranes between its toes to walk on soft ground.



6–7 ft
1.8–2.1 m

MOOSE
Alces americanus
The world's largest deer, inhabiting the forests of North America, the male's palmate antlers contrast with the more typical branched ones of the female.



14–30 in
35–75 cm

SOUTH AMERICAN RED BROCKET
Mazama americana
From the jungles of South America, this small, solitary deer prefers fruit rather than leaves. Males have short, unbranched antlers.

22–28 in
55–70 cm

SOUTH AMERICAN BROWN BROCKET
Mazama gouazoubira
A solitary deer of scrubland and forest thickets in Central and South America, it feeds mainly on fruit and cacti during the dry season.

28–30 in
70–75 cm

PAMPAS DEER
Ozotoceros bezoarticus
A slender deer of South American grasslands and wetlands, the pampas deer stands on its hind legs to browse from tree branches.

14–18 in
35–45 cm

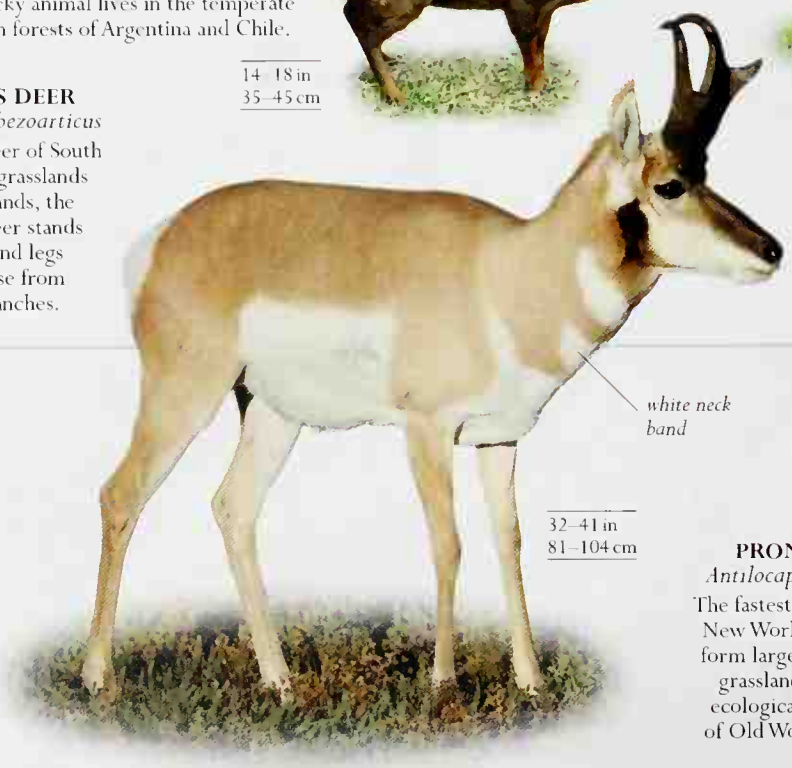
SOUTHERN PUDU
Pudu puda
One of the world's smallest deer, this stocky animal lives in the temperate rain forests of Argentina and Chile.

18–22 in
45–55 cm

CHINESE WATER DEER
Hydropotes inermis
Unlike all other deer, neither sex grows antlers. Their long upper canines protrude as tusks, up to 3¼ in (8 cm) long in males.

PRONGHORN

Widely represented in the North American fossil record, the Antilocapridae included species with bizarrely shaped or multiple horns. Today only the pronghorn survives. With a similar body shape and cloven hooves, the pronghorn resembles antelopes (Bovidae), but unlike them it lacks lateral toes and sheds its horns outside the breeding season.



32–41 in
81–104 cm

PRONGHORN
Antilocapra americana
The fastest mammal in the New World, pronghorns form large herds in open grassland and are the ecological counterpart of Old World antelopes.

BOVIDS

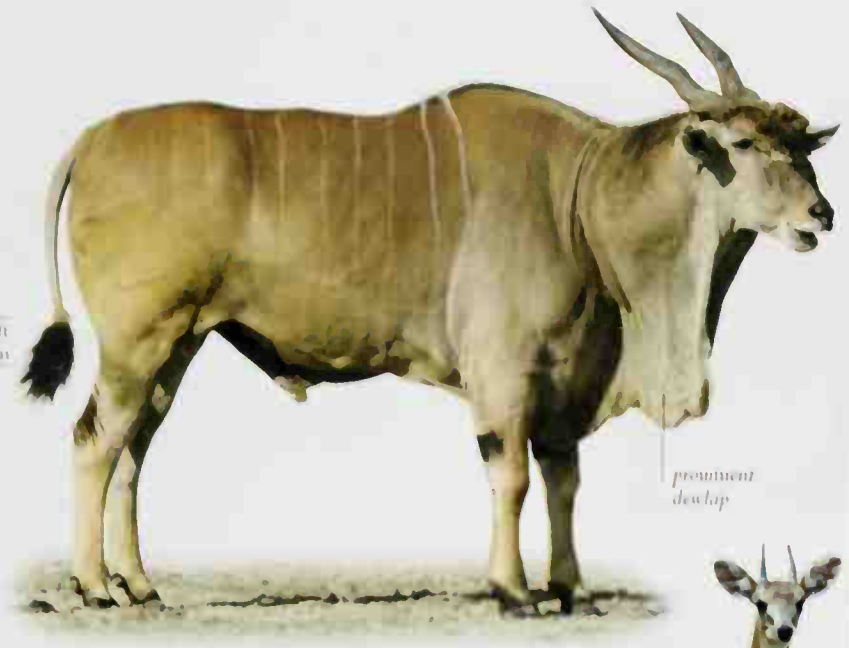
A large and varied family, the Bovidae are found on all continents except Antarctica. Despite their diversity, they share common features: males (and in some species, females) have permanent unbranched horns, often twisted or fluted, and a complex, four-chambered, ruminant's stomach.

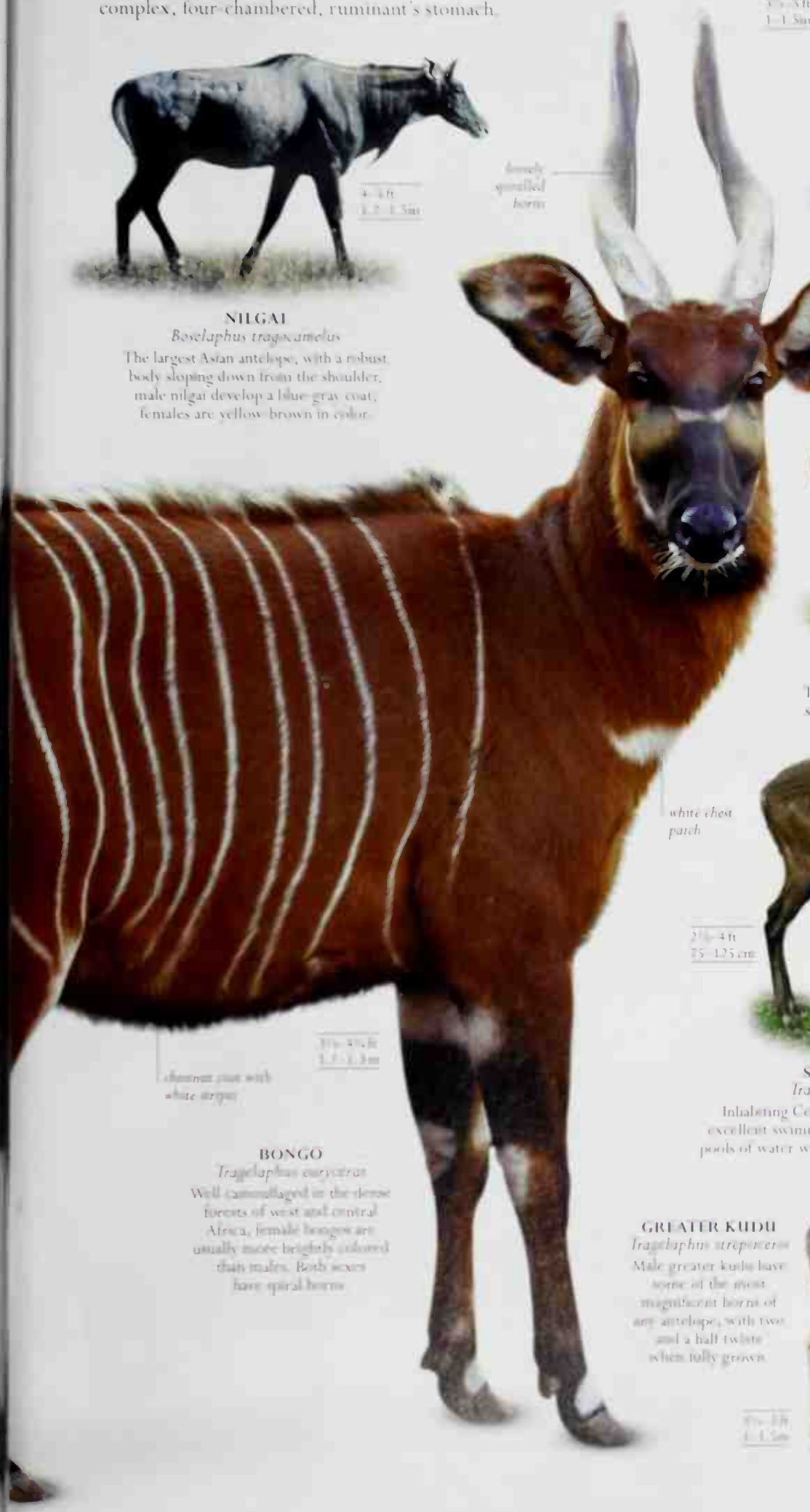
4–4½ ft
1.2–1.5m

NILGAI
Boselaphus tragocamelus
The largest Asian antelope, with a robust body sloping down from the shoulder, male nilgai develop a blue-gray coat, females are yellow-brown in color.

COMMON ELAND
Taurotragus oryx
With spiral horns, the eland is the largest antelope, found in open grassland from Ethiopia to South Africa. Males sometimes develop white stripes down their flanks.

5½–6 ft
1.7–1.8m





3½–4½ ft
1.1–1.3m

BONGO
Tragelaphus eurycerus
Well camouflaged in the dense forests of west and central Africa, female bongos are usually more brightly colored than males. Both sexes have spiral horns.

3–3½ ft
90–110cm

NYALA
Tragelaphus angasii
This southern African forest antelope has spiral horns and a dark brown coat, with vertical white stripes on the sides.

22–26in
55–65cm

FOUR-HORNED ANTELOPE
Tetracerus quadricornis
This solitary Asian forest species usually develops two pairs of horns, one between the ears and the other on the forehead.

24–39in
60–100cm

BUSHBUCK
Tragelaphus scriptus
Widespread in sub-Saharan forests, this species has varied stripes and spots, especially on the face, ears, and tail.

2½–4 ft
75–125cm

SITATUNGA
Tragelaphus spekii
Inhabiting Central African swamps, this excellent swimmer will often take refuge in pools of water when threatened by a predator.

3½–5 ft
1–1.5m

GREATER KUDU
Tragelaphus strepsiceros
Male greater kudu have some of the most magnificent horns of any antelope, with two and a half twists when fully grown.

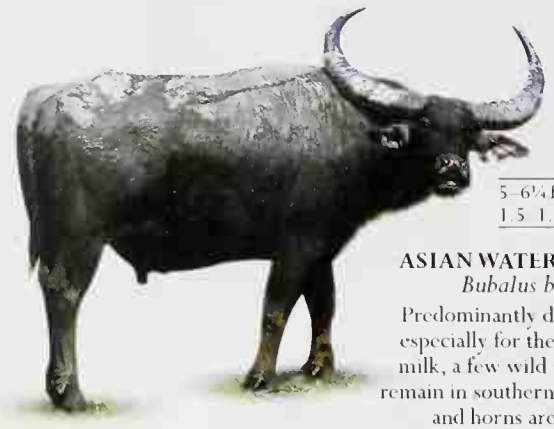
3½–4½ ft
90–110cm

LESSER KUDU
Tragelaphus imberbis
A nocturnal antelope of arid scrubland in northeast Africa, both males and females have about ten white stripes on their coat.

»

3¼–5½ ft
1–1.7 m

AFRICAN BUFFALO
Syncerus caffer
Unpredictable and dangerous, this buffalo cannot be domesticated. Grassland forms have more curved horns than the smaller forest-dwellers.



5–6¼ ft
1.5–1.9 m

ASIAN WATER BUFFALO
Bubalus bubalis
Predominantly domesticated, especially for their power and milk, a few wild water buffalo remain in southern Asia. Coloring and horns are variable.

32–35 in
80–90 cm

LOWLAND ANOA
Bubalus depressicornis
The smallest of all wild cattle, native to the rain forests of Sulawesi, the horns are straight and upright compared with other buffalo.

6–6½ ft
1.8–2 m

AMERICAN BISON
Bison bison
Once roaming North America in huge herds, the few remaining wild bison are dwarfed by captive populations raised for meat and hides.

6–7¼ ft
1.8–2.2 m

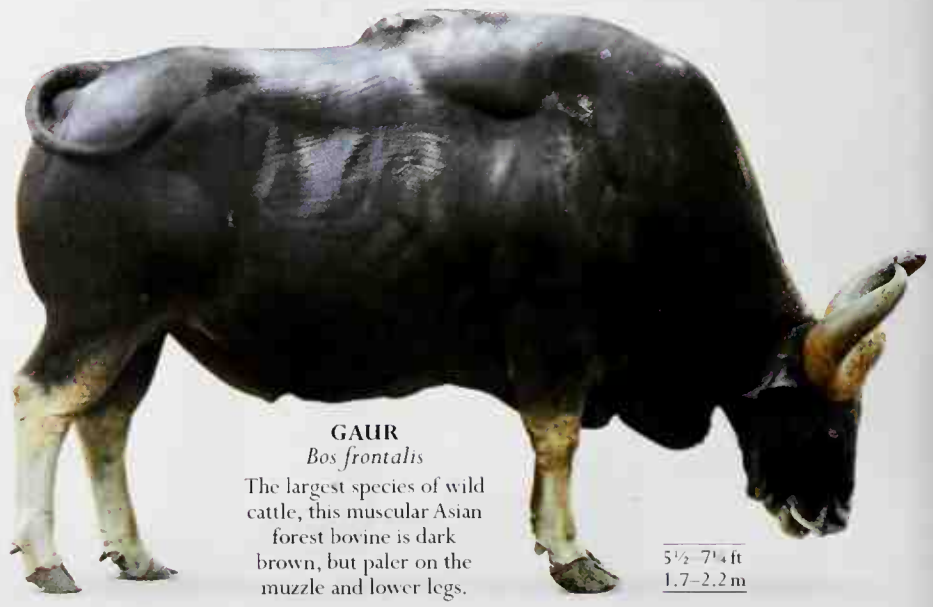
EUROPEAN BISON
Bison bonasus
With shorter hair but longer horns than the American bison, this species is now restricted to eastern European and Russian primary forests.

5¼–5½ ft
1.6–1.7 m

BANTENG
Bos javanicus
Native to southeast Asia and domesticated locally as draft animals, this hovid is brown, with white lower legs, muzzle, rump, and eye spots.

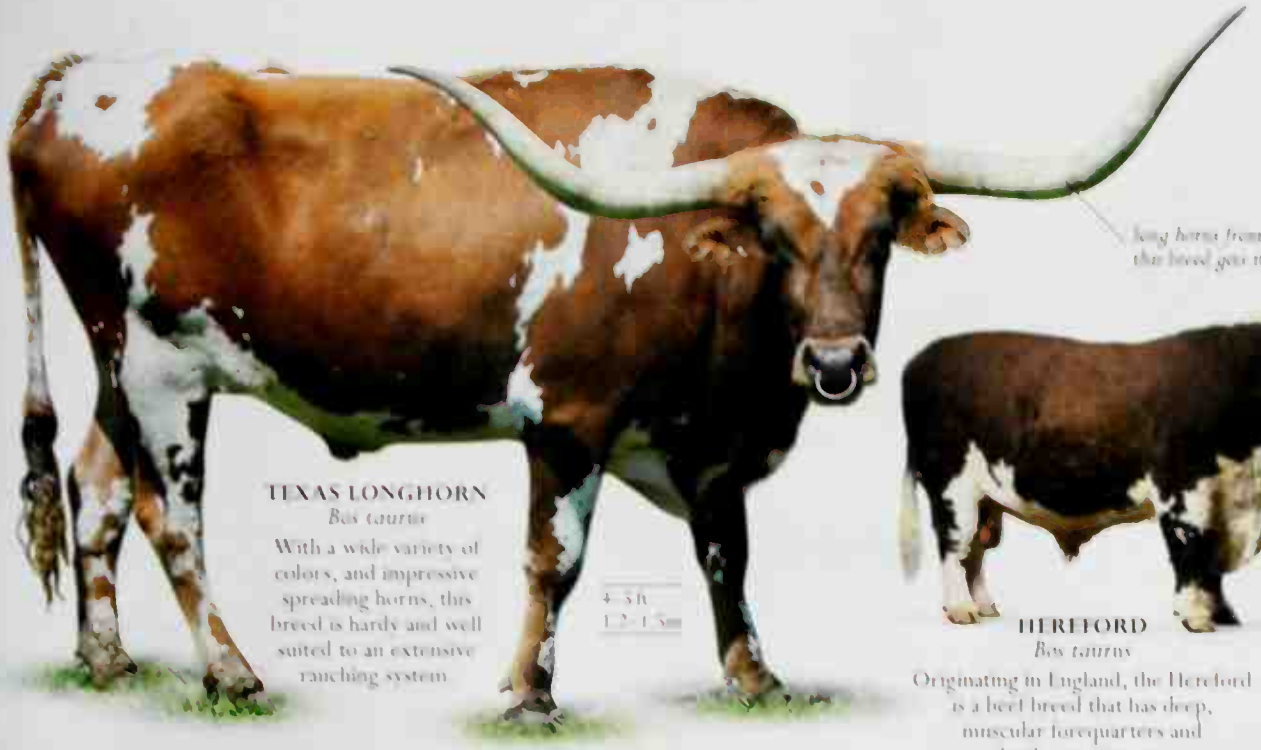
6½–7¼ ft
2–2.2 m

YAK
Bos grunniens
Inhabiting montane parts of Central Asia, insulated with long, shaggy fur, wild yaks are usually brown, but domesticated ones are more varied and many have white markings.



5½–7¼ ft
1.7–2.2 m

GAUR
Bos frontalis
The largest species of wild cattle, this muscular Asian forest bovine is dark brown, but paler on the muzzle and lower legs.



TEXAS LONGHORN
Bos taurus
With a wide variety of colors, and impressive spreading horns, this breed is hardy and well suited to an extensive ranching system.

4–5 ft
1.2–1.5m

HEREFORD
Bos taurus
Originating in England, the Hereford is a beef breed that has deep, muscular forequarters and a docile temperament.

4–5 ft
1.2–1.5m

ANKOLE
Bos taurus
Originating in Africa, the ankole's huge horns, up to 3½ ft (1.8 m) long and very thick, help keep it cool in hot conditions.

4½–5 ft
1.4–1.5m

BRAHMAN
Bos taurus indicus
Originating in Asia, the brahman is now farmed throughout the tropics. Also known as the zebu, it has a characteristic hump on the back.

4–4½ ft
1.2–1.4m

MAXWELL'S DUIKER
Philantomba maxwellii
With a gray-brown coat, this small West African rain forest species has few distinctive features, apart from its pale facial markings.

14–16½ in
35–42 cm

BLUE DUIKER
Philantomba monticola
This small forest antelope from Africa has simple conical horns. It eats eggs, rodents, and ants, in addition to a browser's usual diet.

12½–16 in
32–41 cm

ZEBRA DUIKER
Cephalophus zebra
This is the only duiker without a predominantly plain coat. The stripes provide camouflage in its West African forest-edge habitat.

16–20 in
40–50 cm

JERSEY
Bos taurus
Famed for its rich, creamy milk, this breed was developed on the island of Jersey from stock imported from France.

4–4½ ft
1.2–1.4m

YELLOW-BACKED DUIKER
Cephalophus silvicultor
A large Central African duiker, its dark gray coat has a conspicuous white or yellow patch on the back.

26–34 in
65–87 cm

BLACK-FRONTED DUIKER
Cephalophus nigrifrons
A dark forehead and eye glands, contrasting with paler brows, give this forest dweller from Central Africa a distinctive facial appearance.

18–23 in
45–58 cm

OGILBY'S DUIKER
Cephalophus ogilbyi
From the rain forests of West Africa, this duiker has well-developed hindquarters, with a red-brown rump.

21½–22 in
55–56 cm

COMMON DUIKER
Sylvicapra grimmia
A widespread sub-Saharan antelope with tiny horns, this species occupies a wide range of habitats, often scavenging on fallen fruit.

18–28 in
45–70 cm

26–33 in
65–89 cm

BOHOR REEDBUCK
Redunca redunca
Ranging across the rolling grasslands of Central Africa, the slender female contrasts with the thick-necked, horned male.

SOUTHERN REEDBUCK
Redunca arundinum
A robust antelope in grasslands in southern Central Africa, this species has conspicuous black foreleg markings. Only the males have horns.

26–41 in
65–105 cm

»

3¼–4¼ ft
1–1.3 m

COMMON WATERBUCK
Kobus ellipsiprymnus ellipsiprymnus
Despite its name, this African waterbuck is a savanna and woodland antelope, although it will seek refuge from predators in water.

3¼–4¼ ft
1–1.3 m

DEFASSA WATERBUCK
Kobus ellipsiprymnus defassa
From West and Central Africa, this subspecies of waterbuck has a solid white rump, rather than a white crescent surrounding the tail.

LECHWE
Kobus leche
A highly gregarious antelope that prefers southern Central African marshlands, its long legs enable the lechwe to run well through shallow water.

34–43 in
85–110 cm

32–39 in
80–100 cm

UGANDA KOB
Kobus kob thomasi
A sociable antelope from East Africa, the Uganda kob has a distinct white throat patch. Males have ridged, lyre-shaped horns.

30–33 in
77–83 cm

PUKU
Kobus vardonii
Very similar to the kob, but from southern Central Africa, the puku is slightly smaller and more stocky.

3–3¾ ft
95–115 cm

ADDAX
Addax nasomaculatus
This endangered antelope from the Sahara has long horns with two or three spiral twists, and a pale sandy or whitish coat.

ROAN ANTELOPE
Hippotragus equinus
The ridged horns of this sub-Saharan savanna antelope grow in a smooth curve. The animal has a distinctive black and white face.

4–5 ft
1.2–1.5 m

long, thin, curved horns

SCIMITAR-HORNED ORYX
Oryx dammah
Formerly ranging across the Sahara, this whitish oryx was almost hunted to extinction in the 20th century, but has been reintroduced to some areas.

4–4½ ft
1.2–1.4 m

SABLE ANTELOPE
Hippotragus niger
A powerful antelope with a dark coat and striking white face markings, its magnificent horns can reach more than 3 ft (1 m) in length.

35–55 in
90–140 cm

ARABIAN ORYX
Oryx leucoryx
White-coated, with long, straight horns, this antelope has recently been reintroduced to parts of its former Middle Eastern range.

rusty colored chest and neck

3¼–4¼ ft
1–1.3 m

relatively short, sturdy legs

BEISA ORYX
Oryx beisa
Gray-brown, marked with black on the face, tail, flanks, and front legs, this East African desert oryx has very long, barely curved horns.

3¼–4 ft
1–1.25 m

4–4½ ft
1.2–1.4 m

GEMSBOK
Oryx gazella
The largest oryx, the gemshok frequents arid habitats in southern Africa, but has also been successfully established in North America.

HARTEBEEST
Alcelaphus buselaphus
A large, long-faced antelope that lives on open grassland in eastern Africa. There are several subspecies, differing in color and horn shape.

5½–5ft
1.1–1.5m

RED HARTEBEEST
Alcelaphus caama
Chestnut brown, with a darker face and tail, this antelope is sometimes treated as a subspecies of the hartebeest.

5½–5ft
1.1–1.5m

KLIPSPRINGER
Oreotragus oreotragus
Meaning "rock jumper" in Afrikaans, the klipspringer inhabits rocky outcrops. It can leap more than ten times its own height.

1ft–23in
43–58cm

20–26in
50–66cm

ORIBI
Ourebia ourebi
A graceful, long-necked antelope from sub-Saharan Africa, the oribi has a distinctive white brow line and a large, dark facial gland.

3½–5ft
1.1–1.5m

LICHTENSTEIN'S HARTEBEEST
Alcelaphus lichtensteinn
Distinguished by its strongly curved horns that turn inward at their tips, this hartebeest is found in savanna and floodplain grassland in Central Africa.

heavy, recurved horns

sloping back

black face

4–5ft
1.2–1.5m

BLUE WILDEBEEST
Connochaetes taurinus taurinus
A highly gregarious, African antelope, also known as a brindled gnu, this species is found in savanna regions of southern Africa.

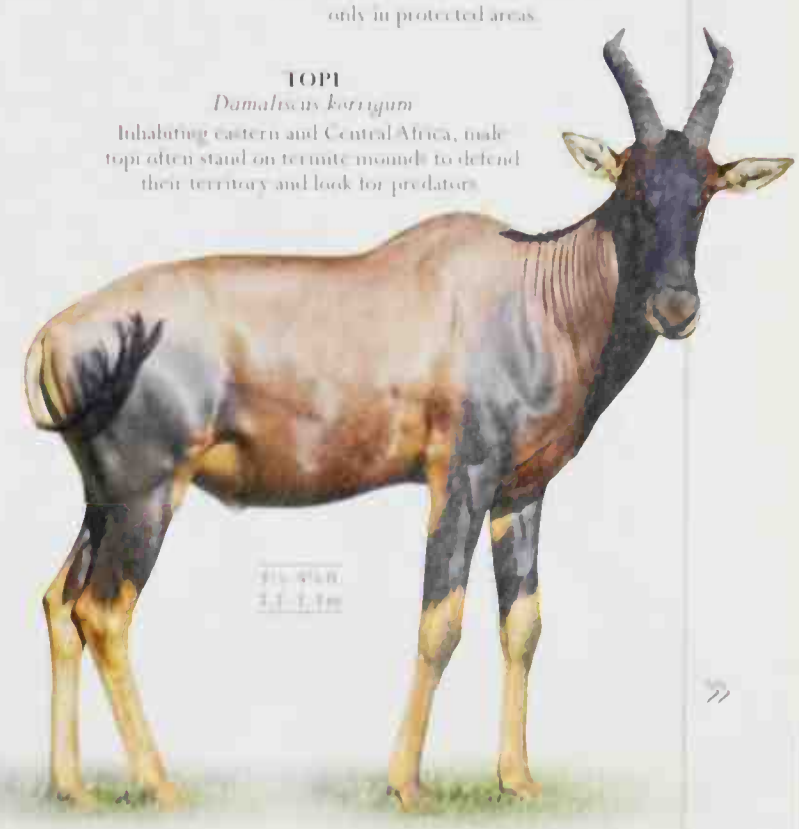
dark gray coat

32–39in
80–100cm

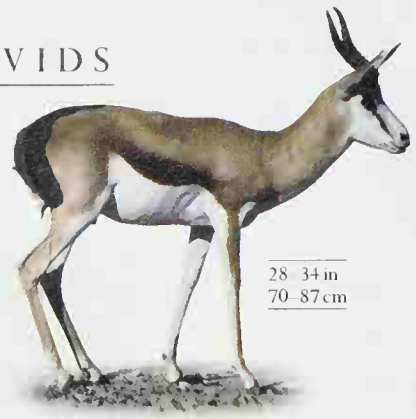
long, black throat hair

BONTEBOK
Damaliscus pygargus dorcas
With a striking white face patch, this South African antelope was hunted almost to extinction. It is now found only in protected areas.

TOPI
Damaliscus korrigum
Inhabiting eastern and Central Africa, male topi often stand on termite mounds to defend their territory and look for predators.



4½–5ft
1.3–1.5m



28–34 in
70–87 cm

SPRINGBOK
Antidorcas marsupialis
With its numbers much reduced by hunting, this agile antelope, with lyre-shaped horns, browses the arid lands of southern Africa.

21–26 in
53–67 cm

THOMSON'S GAZELLE
Eudorcas thomsonii
The most numerous gazelle on the plains of East Africa, this species has a broad black stripe on its sides.

23½–34 in
60–85 cm

BLACKBUCK
Antilope cervicapra
With the ability to reach speeds of 50 mph (80 kph), the blackbuck inhabits grassland and open woodland in India and Pakistan.

13½–15 in
34–38 cm

21–26 in
53–65 cm

DORCAS GAZELLE
Gazella dorcas
Inhabiting deserts from North Africa to the Middle East, this small gazelle can survive without drinking, taking moisture from its food.

23½–28 in
60–70 cm

MOUNTAIN GAZELLE
Gazella gazella
From the mountains and plains of the Middle East, this gazelle has several isolated subspecies, some extremely rare and threatened by poaching.

22–32 in
56–80 cm

GOITERED GAZELLE
Gazella subgutturosa
Named for the bulging larynx of the rutting male, this Central Asian gazelle is unique in that only the male has horns.

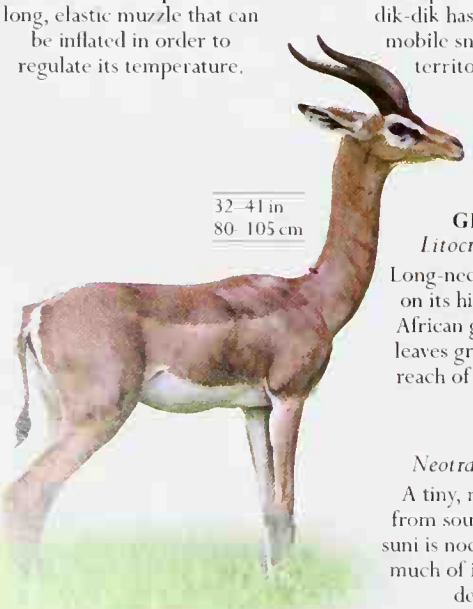
14–18 in
35–45 cm

KIRK'S DIK-DIK
Madoqua kirkii
A tiny antelope, named for its sharp alarm note, Kirk's dik-dik has an elongated, mobile snout. It forms territorial pairs.

GÜNTHER'S DIK-DIK
Madoqua guentheri
A dik-dik of the East African semideserts, this species has a long, elastic muzzle that can be inflated in order to regulate its temperature.

23½–32 in
60–80 cm

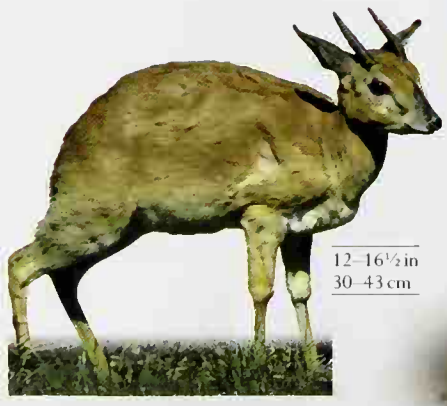
STEPPE SAIGA
Saiga tatarica
Now highly endangered and found only in the central Asian steppes, the saiga's enlarged, flexible nose warms cold winter air and filters out summer dust.



32–41 in
80–105 cm

GERENUK
Litocranius walleri
Long-necked and standing on its hind legs, the East African gerenuk browses leaves growing out of the reach of other antelopes.

SUNI
Neotragus moschatus
A tiny, reddish antelope from southeast Africa, the suni is nocturnal and spends much of its time hidden in dense scrub.



12–16½ in
30–43 cm

35–43 in
90–110 cm

DAMA GAZELLE
Nanger dama
This rare Saharan gazelle is strikingly bicolored. The amount of white varies between subspecies, although all have a white throat patch.

30–36 in
76–91 cm

GRANT'S GAZELLE
Nanger granti
Frequenting the East African plains, this gazelle can survive without drinking water, so it does not follow the migrations of many of its relatives.

24–35 in
60–90 cm

SOEMMERRING'S GAZELLE
Nanger soemmerringii
Similar to, but much rarer than Grant's gazelle, this East African species is distinguished by its stronger face pattern and larger white rump patch.

18–24 in
45–60 cm

STEENBOK
Raphicerus campestris
A small East African bush antelope, the steenbok has particularly large, white-lined ears, with black margins and internal markings.

18–24 in
45–60 cm

SHARPE'S GRYSBOK
Raphicerus sharpei
Shy and solitary, with stubby horns, this nocturnal antelope from eastern Africa takes refuge from predators in the burrows of aardvarks.

29–36 in
73–92 cm

IMPALA
Aepyceros melampus
An African plains antelope, with lyre-shaped horns in the male, the impala is an important source of food for the big cats of the region.

28–34 in
70–85 cm

ALPINE CHAMOIS
Rupicapra rupicapra
Living high among mountain rocks in the upland blocks of southern Europe and Asia Minor, this species occurs in isolated populations. Each has a subtly different appearance.

27½–31 in
57–78 cm

HIMALAYAN GORAL
Naemorhedus goral
A rough-haired, goatlike browser with curved horns, the goral lives in small herds in the forests of the Himalayas.

30–38 in
76–97 cm

SUMATRAN SEROW
Capricornis sumatraensis
A goat-antelope, with coarse fur and a distinct mane, the Sumatran serow lives on forested mountain slopes where it feeds on grass and leaves.

white coat has down underfur for warmth

42–55 in
80–95 cm

MOUNTAIN GOAT
Oreamnos americanus
A sure-footed climber from the northern Rocky Mountains, this goat has a dense, woolly white coat to protect it from low temperatures and high winds.

»

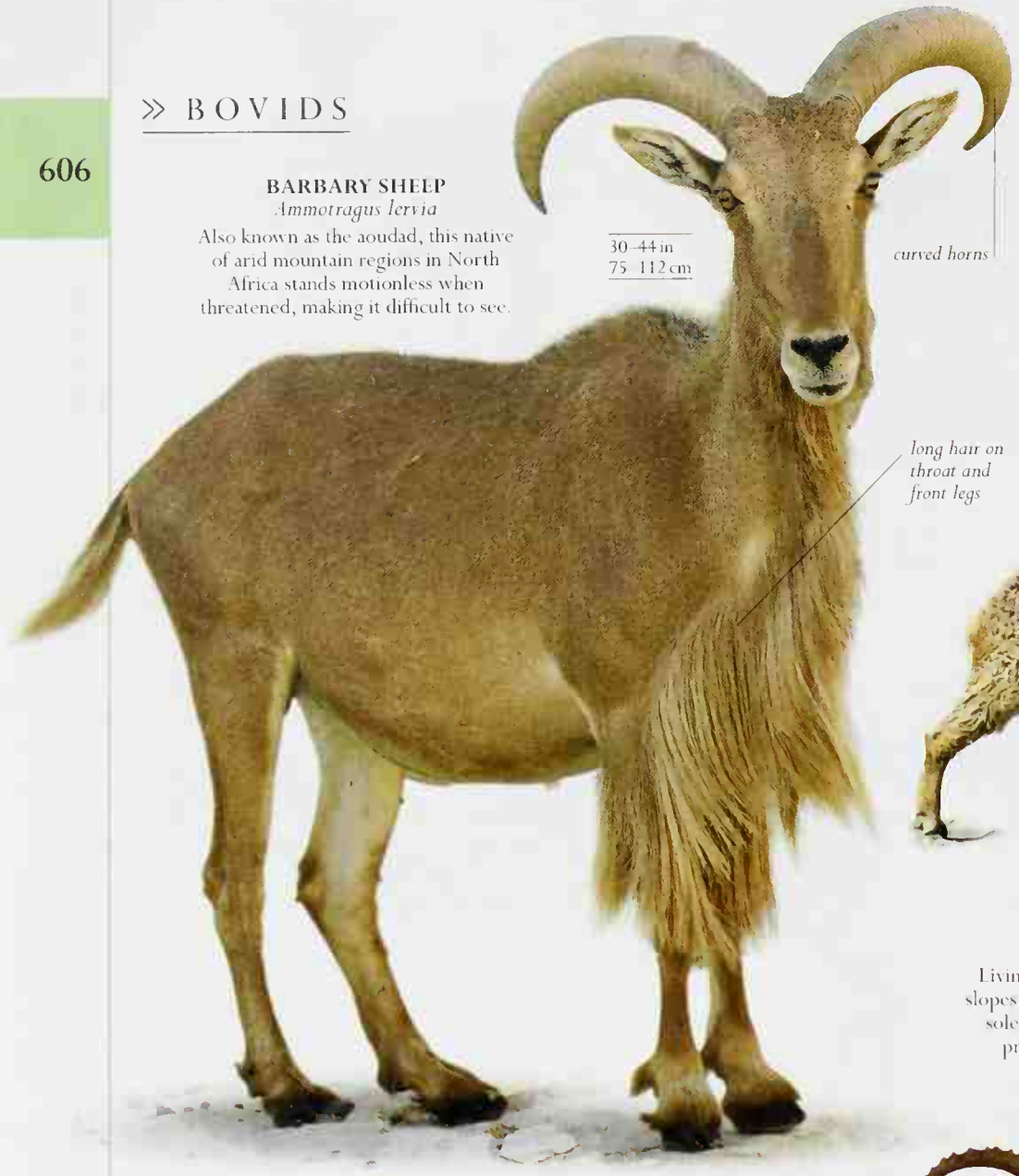
BARBARY SHEEP
Ammotragus lervia

Also known as the aoudad, this native of arid mountain regions in North Africa stands motionless when threatened, making it difficult to see.

30–44 in
75–112 cm

curved horns

long hair on throat and front legs



4–4½ ft
1.2–1.4 m

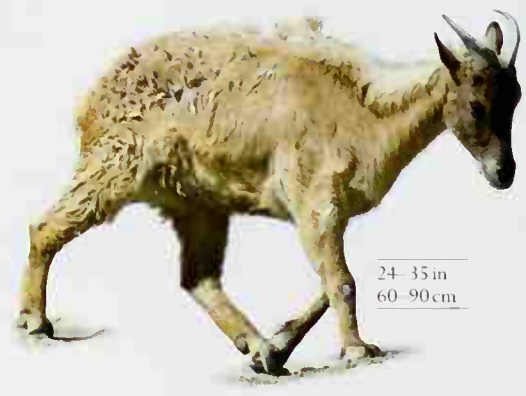
MUSKOX
Ovibos moschatus

An inhabitant of Arctic tundra, the muskox has a shaggy coat, with dense insulating underwool, which provides protection against the elements.

3¼–4¼ ft
1–1.3 m

TAKIN
Budorcas taxicolor

Living in small herds in the mountain forests of China and Bhutan, the takin has shaggy fur and a broad, arched muzzle.



24–35 in
60–90 cm

HIMALAYAN TAHR
Hemitragus jemlahicus

Living on rocky Himalayan mountain slopes, the tahr has hooves with rubbery soles, which give additional grip on precipitous or unstable ground.

30–35 in
75–90 cm

BHARAL
Pseudois nayaur

From rocky deserts to mountain slopes on the Tibetan Plateau, this species stays close to cliffs, its refuge from predators.

20–41 in
50–105 cm

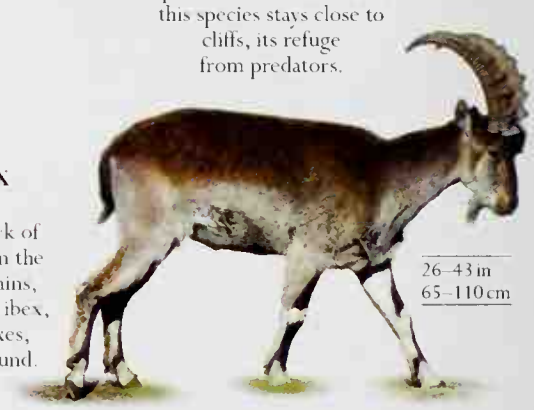
ALPINE IBEX
Capra ibex

Living above the tree line in the Alps, ibex have recurved horns up to 3¼ ft (1 m) long that are especially impressive on males.

24–35 in
60–90 cm

NUBIAN IBEX
Capra nubiana

Closely related to, and perhaps a subspecies of, the Alpine ibex, this species inhabits desert mountains of the Middle East.



26–43 in
65–110 cm

WALIA IBEX
Capra walie

Due to the the lack of seasonal changes in the Ethiopian mountains, this rare species of ibex, unlike other ibexes, breeds all year round.

26–45 in
65–115 cm

MARKHOR
Capra falconeri

The largest wild goat, from the mountains of central Asia, is endangered by hunting for its impressive corkscrew horns and meat.

36–44 in
92–112 cm

ANGORA GOAT
Capra hircus

This breed of goat, originating in Turkey, has a fleece that is much valued as the source of mohair, a durable silky fiber.

28–39 in
70–100 cm

BAGOT GOAT
Capra hircus

One of more than 300 goat breeds, the Bagot was bred in England from stock brought home in the 13th century by the returning Crusaders.

28–35 in
70–90 cm

GOLDEN GUERNSEY GOAT
Capra hircus

A small goat, often with long hair, this rare breed is kept for milk and showing, and originated on Guernsey in the Channel Islands.

35–39 in
90–100 cm

MOUFLON
Ovis aries orientalis

With a reddish coat and pale saddle, this native of Asia Minor has been established on several Mediterranean islands since Neolithic times.

26–32 in
65–80 cm

MANX LOAGHTAN SHEEP
Ovis aries

Originating on the Isle of Man, this primitive, hardy breed, kept for its meat, has brown wool and usually four horns.

26–39 in
65–100 cm

COTSWOLD SHEEP
Ovis aries

Originating in England, this white-faced breed is hardy and dual-purpose, kept for its long wool and its meat.

26–32 in
65–80 cm

JACOB SHEEP
Ovis aries

This ancient, hardy breed, with a patterned coat, is said to have originated in Palestine. It has as many as three pairs of horns.

35–49 in
90–125 cm

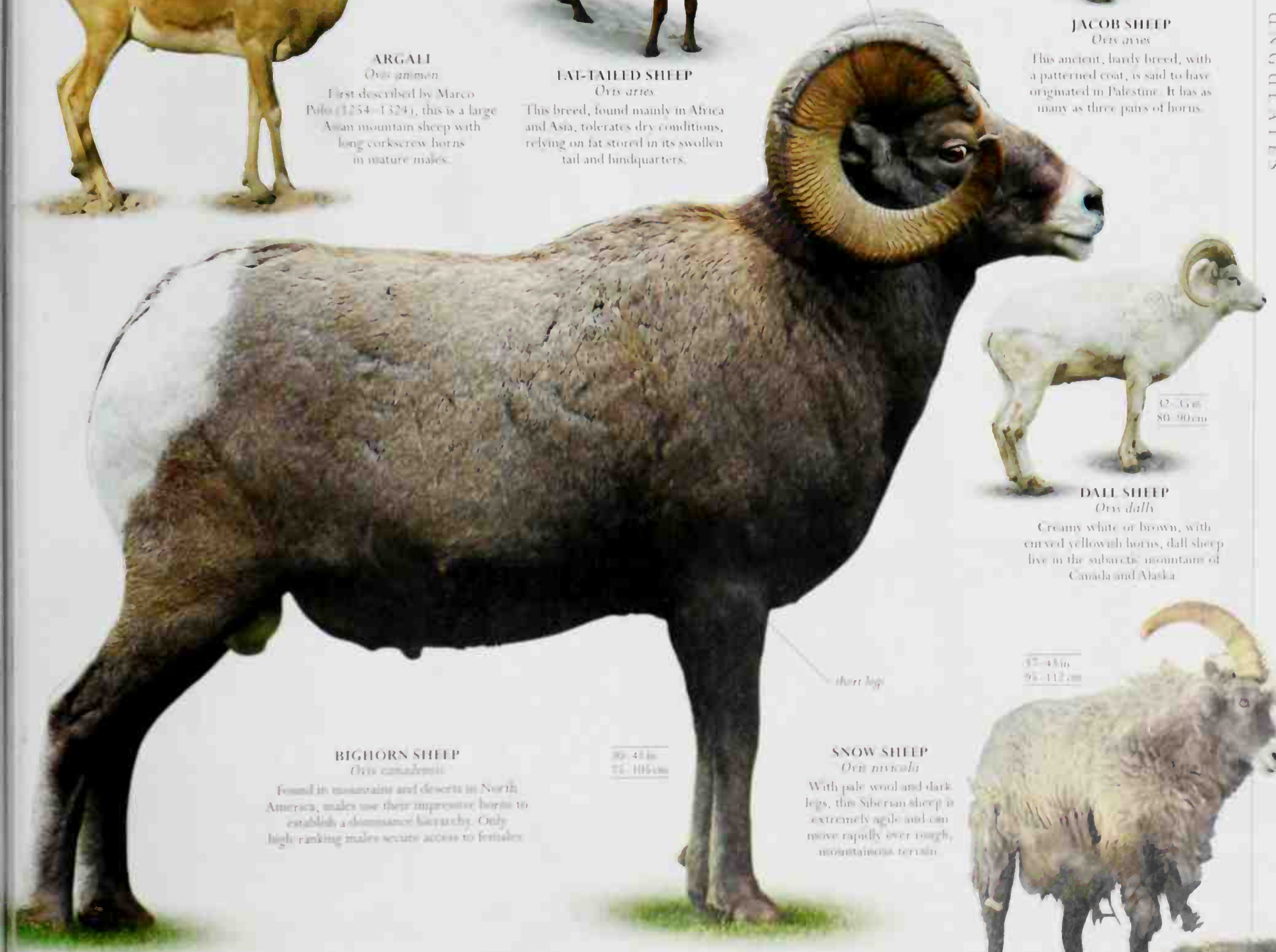
ARGALI
Ovis ammon

First described by Marco Polo (1254–1324), this is a large Asian mountain sheep with long corkscrew horns in mature males.

26–43 in
65–110 cm

FAT-TAILED SHEEP
Ovis aries

This breed, found mainly in Africa and Asia, tolerates dry conditions, relying on fat stored in its swollen tail and hindquarters.



BIGHORN SHEEP
Ovis canadensis

Found in mountains and deserts in North America, males use their impressive horns to establish a dominance hierarchy. Only high-ranking males secure access to females.

30–41 in
75–105 cm

SNOW SHEEP
Ovis nivicola

With pale wool and dark legs, this Siberian sheep is extremely agile and can move rapidly over rough, mountainous terrain.

32–35 in
80–90 cm

DALL SHEEP
Ovis dalli

Creamy white or brown, with curved yellowish horns, dall sheep live in the subarctic mountains of Canada and Alaska.

37–44 in
95–112 cm

GIRAFFE AND OKAPI

Diverse in the fossil record, the Giraffidae is represented now by just two species from sub-Saharan Africa. Although very different in shape and habitat, they share some common features, including a long, dark tongue, ossicones (horns) covered in skin, and lobed canine teeth. Otherwise they resemble the bovids, with cloven hooves, a four-chambered stomach, and the incisors (upper front teeth) replaced by a horny pad.

5–6½ ft
1.5–2 m

OKAPI
Okapia johnstoni
Restricted to the rain forests of Central Africa, the okapi's long neck and flexible blue tongue show clear similarities to the giraffe.

short horns covered in skin

large ears

short upright mane

short body with sloping back

8¼–11 ft
2.5–3.3 m

ROTHSCHILD'S GIRAFFE
Giraffa camelopardalis rothschildi
Unlike most giraffe races, this subspecies has white "socks"—its blotches do not extend onto the lower leg.

8¼–12 ft
2.5–3.6 m

MASAI GIRAFFE
Giraffa camelopardalis tippelskirchi
With a neck up to 7¾ ft (2.4 m) long on top of the shoulder height, this is the largest subspecies of the world's tallest mammal.

8¼–11 ft
2.5–3.3 m

irregular blotches

RETICULATED GIRAFFE
Giraffa camelopardalis reticulata
Ranging from northern Kenya to Ethiopia, this race of giraffe has large polygonal blotches, often with pale centers, on a pale background.

THORNICROFT'S GIRAFFE
Giraffa camelopardalis thornicrofti
With star-shaped or lobed blotches that extend onto the lower leg, this race is found in eastern Zambia.

CAMELS AND RELATIVES

Unique within their order, members of the family Camelidae have just two toes, but no hooves. Each toe has a small nail at its tip and a soft footpad, which can shift slightly to help maintain grip in mountainous terrain and prevent sinking in soft sand. They also have distinctive teeth, oval red blood cells, a three-chambered stomach, and a leg musculature that entails lying down resting on their knees.

DROMEDARY
Camelus dromedarius
Used for transport in arid regions, this Arabian species is supremely adapted to desert life. Only the feral Australian populations show wild characteristics.

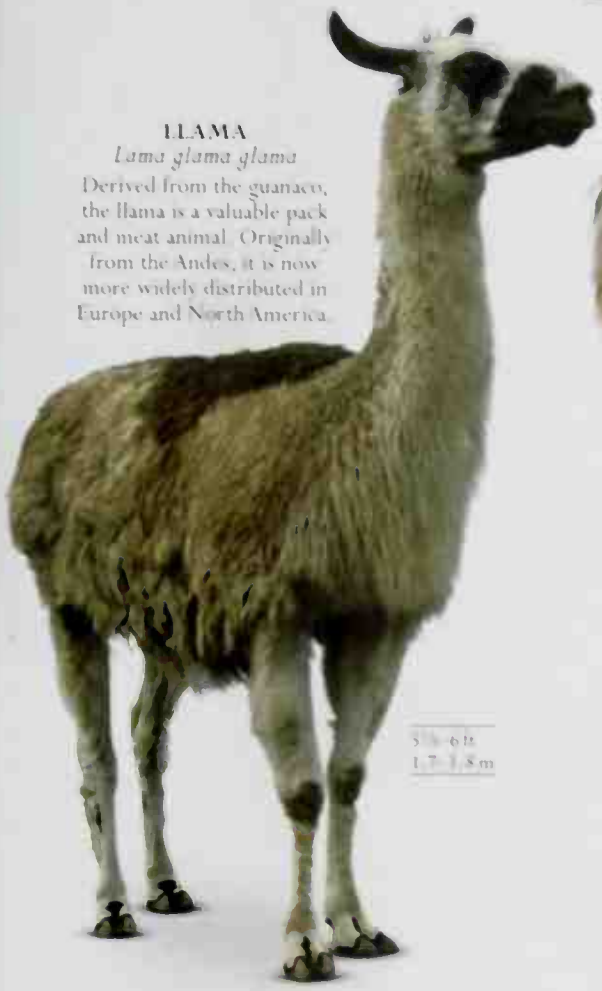
5½–6½ ft
1.7–2 m

6–7½ ft
1.8–2.3 m

BACTRIAN CAMEL
Camelus bactrianus
Widely domesticated, as a wild animal the two-humped camel is restricted to critically small populations in the Asian deserts.

30–34 in
75–85 cm

VICUÑA
Vicugna vicugna
The smaller of the two wild Andean camelids, the vicuña produces a fine wool, which led to its domestication and development of the alpaca.



LLAMA
Lama glama glama
Derived from the guanaco, the llama is a valuable pack and meat animal. Originally from the Andes, it is now more widely distributed in Europe and North America.

5½–6 ft
1.7–1.8 m

GUANACO
Lama glama guanicoe
Native to the arid mountains of South America, the guanaco has high levels of oxygen-carrying hemoglobin in the blood, enabling it to thrive at extreme altitudes.

3½–4 ft
1.1–1.2 m

30–35 in
75–90 cm

ALPACA
Vicugna pacos
Kept in herds that graze high in the Andes, and now elsewhere in the world, this species is an important source of wool.

HIPPOPOTAMUSES

Among the Artiodactyla, family Hippopotamidae is unique in that its members walk on four toes on each foot. They also have huge, barrel-shaped bodies, short but stout legs, and large heads. Their wide mouths, with tusklike canine teeth, are used in feeding, fighting, and defense. Reflecting an amphibious lifestyle, the nostrils and eyes are on the top of the snout and the skin is smooth, lacking sweat glands.

30–32 in
75–80 cm

PYGMY HIPPOPOTAMUS
Choeropsis liberiensis
An inhabitant of the forested swamps of West Africa, this species is similar in shape to its larger relative, but its muzzle is proportionally smaller.

4½–5½ ft
1.3–1.7 m

HIPPOPOTAMUS
Hippopotamus amphibius
A solitary nocturnal grazer and social daytime wallower, this species is now found mainly in eastern and southern Africa.

BACTRIAN CAMEL
Camelus bactrianus

The Bactrian camel is an exceptionally hardy animal, built to survive in the harsh desert landscapes of southern Asia, where temperatures range between 104°F (40°C) in summer and -20°F (-29°C) in winter. Camels are adapted to travel long distances over difficult terrain in search of food—such as grasses, leaves, and shrubs—which is scarce. When water is available, the Bactrian camel is able to gulp more than 26 gallons (100 liters) in 10 minutes. It can also survive by drinking salty water if necessary. Almost all of the world's Bactrian camels are domesticated; fewer than 1,000 animals remain in the wild, in remote and inhospitable parts of China and Mongolia. Recent studies suggest that these wild camels are genetically distinct from the domestic variety, making it all the more urgent that they be conserved.

closable nostrils keep sand out

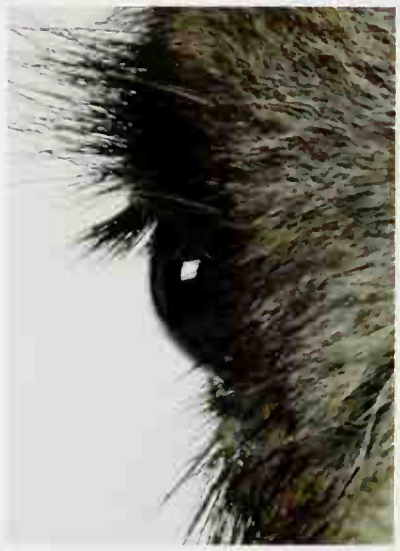
small, furry ears

thick fur keeps the camel warm, and also protects it from sunburn

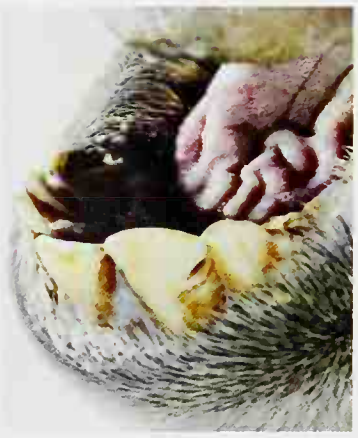
shaggy mane

SIZE 6–7½ ft (1.8–2.3 m)
HABITAT Stony desert, steppe, and rocky plains
DISTRIBUTION Asia
DIET Herbivorous

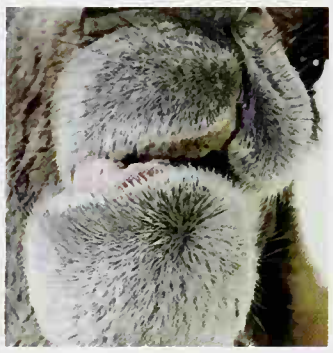
v EYELASHES
Two rows of extra thick eyelashes protect the eyes from strong sunlight, and windblown sand and grit, saving precious water from being blinked away as tears.



v KNEE PADS
The thick pads of skin on the knees are used for kneeling. Camels rest on their knees, with their legs folded beneath them.



^ TEETH
Camels swallow their food whole, then regurgitate and rechew it to aid digestion. Starving individuals have been known to eat rope and leather, which are hard to break down.



^ MOUTH
A groove connecting to the upper lip channels any valuable moisture that trickles from the camel's nostrils back into its mouth—nothing is wasted.

< ^ FEET
The feet each have two toes and a tough padded sole that allows the camel to cope equally well with sharp stony ground, hot sand, or compacted snow.

humps contain reserves of fat
distinctive second hump
elbow pad
belly needs little protection from sunburn, so the coat here is thin, allowing heat to be shed
knee pad
paired toes

DESERT TRAVELS

Camels are long-legged nomads, able to travel 30 miles (50 km) a day and go without food or water for weeks. This extraordinary resilience makes them ideal beasts of burden in arid areas. Bactrian camels eat a wide range of plant foods, and have a large stomach with three chambers in which tough food is slowly broken down. In undernourished camels, the humps become floppy as the reserves of fat are used up.

WHALES, PORPOISES, AND DOLPHINS

Collectively known as cetaceans, this group of mammals is wholly aquatic and all but four species in the order are found in coastal and marine waters.

Supremely adapted to life in water, the cetacean body is tapered and streamlined, with the forelimbs modified into flippers. There are no visible hind limbs, but the tail has horizontal flukes for added propulsion. Many species also have a dorsal fin. The skin is almost hairless and the body is insulated by a layer of blubber, which is especially thick in species living in cold water.

BREATHING AND COMMUNICATING

Capable of diving to great depths and for long periods because of their ability to store oxygen in their muscle tissues, cetaceans must come to the surface to breathe. Breathing is through nostrils, known as blowholes, which are located on the top of the head. When stale air is expelled, it may create a spout of condensation—the spout's size, angle, and shape can be used to distinguish some species, even when their body is almost fully submerged.

Most species produce sound. Some use a series of clicks for echolocation. The clicks bounce off nearby objects, alerting them to any obstacles on their path. Others communicate with each other using vocalizations that range from whistles and groans to the complex songs of many great whales. While their hearing is good, their ears are reduced to simple openings behind the eyes. External ears are both undesirable—they would affect streamlining—and unnecessary, since water is an effective medium for sound transmission.

HUNTER OR FILTER-FEEDER

Cetaceans are divided into two main groups based on their feeding habits. Toothed species, predators of fishes, large invertebrates, seabirds, seals, and sometimes smaller cetaceans, catch prey with their sharp teeth and usually swallow it whole, without chewing. In contrast, filter-feeding baleen whales have fibrous baleen plates suspended from their upper jaw that act like sieves. Water, containing invertebrates and small fishes, is taken in and then forced out through the plates by the tongue, leaving behind the organisms.

PHYLUM	CHORDATA
CLASS	MAMMALIA
ORDER	CETACEA
FAMILIES	12
SPECIES	About 90

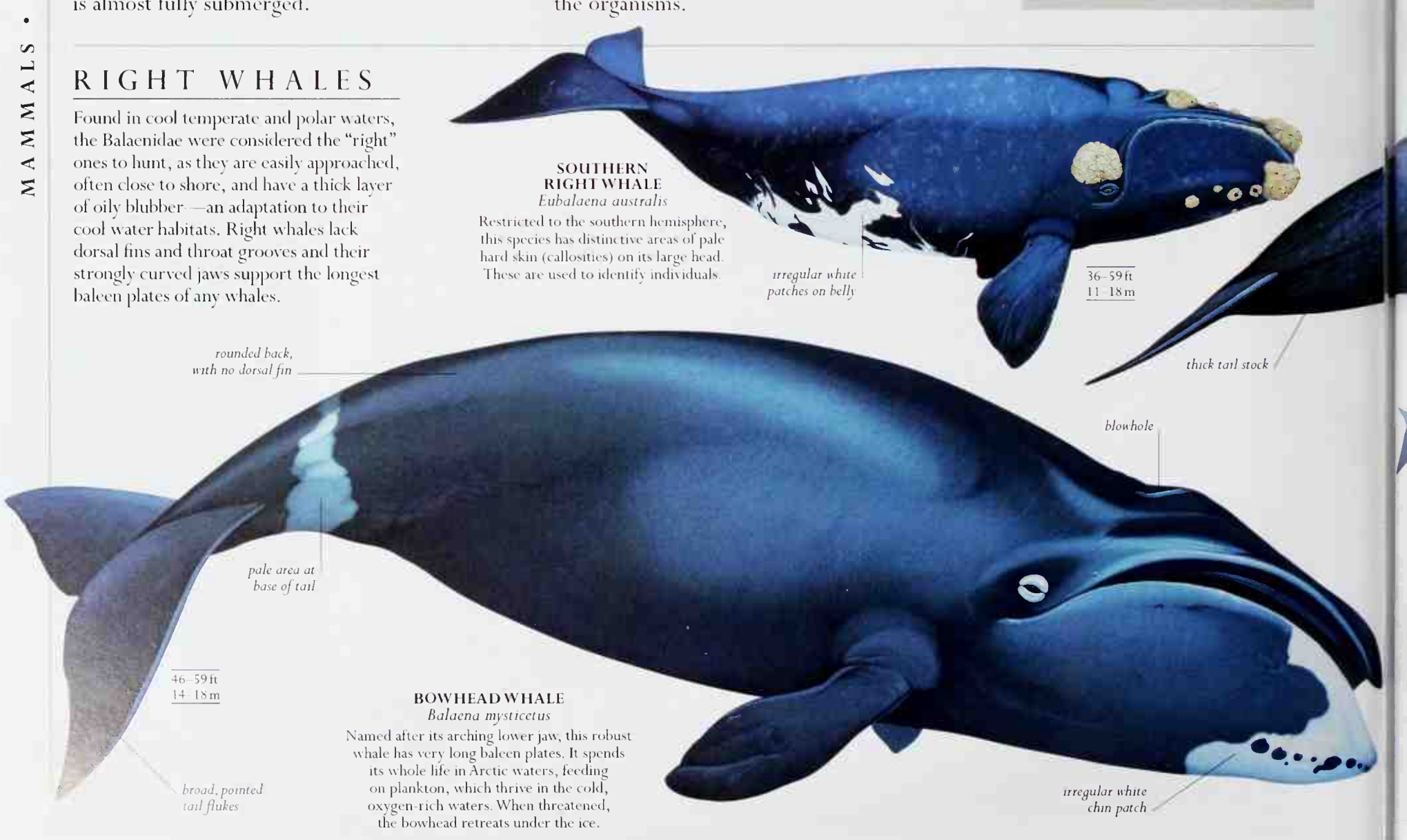
DEBATE

LAND-LIVING ANCESTORS

The taxonomic position of cetaceans has long been debated; their extreme adaptation to a wholly aquatic lifestyle masks anatomical features that are shared with other orders. Today it is generally accepted that Cetacea is most closely related to Artiodactyla—specifically the hippopotamus family—so they are grouped together as Cetartiodactyla, at order or superorder level. Evidence comes mainly from genetic and molecular studies, but there is increasing anatomical support, including strong similarities between the ankle bones of artiodactyls and some fossil ancestors of whales.

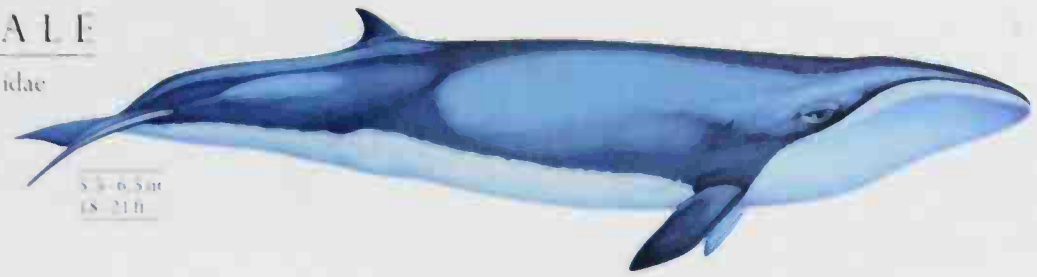
RIGHT WHALES

Found in cool temperate and polar waters, the Balaenidae were considered the "right" ones to hunt, as they are easily approached, often close to shore, and have a thick layer of oily blubber—an adaptation to their cool water habitats. Right whales lack dorsal fins and throat grooves and their strongly curved jaws support the longest baleen plates of any whales.


SOUTHERN RIGHT WHALE
Eubalaena australis
Restricted to the southern hemisphere, this species has distinctive areas of pale hard skin (callosities) on its large head. These are used to identify individuals.
irregular white patches on belly
36–59 ft
11–18 m
thick tail stock
rounded back, with no dorsal fin
blowhole
pale area at base of tail
46–59 ft
14–18 m
BOWHEAD WHALE
Balaena mysticetus
Named after its arching lower jaw, this robust whale has very long baleen plates. It spends its whole life in Arctic waters, feeding on plankton, which thrive in the cold, oxygen-rich waters. When threatened, the bowhead retreats under the ice.
broad, pointed tail flukes
irregular white chin patch

PYGMY RIGHT WHALE

Consisting of one species, the family Neobalaenidae is confined to waters in the southern hemisphere. Unlike most true right whales, the pygmy right whale has a small, prominent dorsal fin, but no callosities on the head. Its baleen plates are ivory in colour.



PYGMY RIGHT WHALE
Caperea marginata
The smallest baleen whale, this species is poorly known because of its sparse population. It has short flippers and a weakly arched jaw.

RORQUALS

The largest family of baleen whales, rorquals are named after the Norwegian word for "furrow whale". The furrows on their throat enable them to expand the mouth while filter-feeding. Most of the Balaenopteridae breed in temperate waters, moving to polar feeding grounds in summer. Slender and streamlined, they have long flippers and a dorsal fin set towards the rear of the body.

HUMPBACK WHALE
Megaptera novaeangliae
This distinctive whale is very active, often revealing tail flukes with individually recognizable markings. It may bubble net to catch food by surrounding it with exhaled air bubbles.

FIN WHALE
Balaenoptera physalus
Dubbed the "greyhound of the sea" for its speed, this whale has a distinctive asymmetrical jaw coloration. Often gregarious, it can occur in groups of up to six or more.

BRYDE'S WHALE
Balaenoptera edeni
Found in shallow tropical and subtropical waters around the globe, this whale is distinguished by the three ridges on its snout.

BLUE WHALE
Balaenoptera musculus
The largest living animal on the planet, the blue whale has a more tapering, elongated body than any other large whale, and a small, stubby dorsal fin.

SEI WHALE
Balaenoptera borealis
Mainly found in temperate waters, the sei whale is a fast-moving rorqual. Dark gray above and pale below, it has a large, curved dorsal fin.

MINKE WHALE
Balaenoptera acutorostrata
The smallest rorqual, this species has a pointed snout, with a prominent ridge running from the blowhole. Its flippers usually show white patches.

GRAY WHALE

The sole species in the family Eschrichtiidae is now restricted to the eastern North Pacific, having been hunted to extinction in the Atlantic. It undertakes vast annual migrations—the longest of any mammal—from the Bering Sea to breed in subtropical waters, especially off Baja California, Mexico.

GRAY WHALE
Eschrichtius robustus
Lacking a dorsal fin, the gray whale's back has a low hump, with a series of smaller "knuckles" behind. The throat grooves are poorly developed.

BEAKED WHALES

The Ziphiidae are found in the open ocean, typically in small groups that congregate around underwater canyons. They feed near the sea floor, diving for an hour or more. Their facial beaks usually have one or two pairs of teeth, which are for display only—food is simply sucked in. Because of their remote habitat and ability to dive deep, few of the 20 species in the family are familiar; some have never been sighted alive.

15–18 ft
4.5–5.5 m

GRAY'S BEAKED WHALE
Mesoplodon grayi
Found throughout the Southern Hemisphere, this is one of the few beaked whales with numerous teeth. Its long, slender beak is often whitish.

15–20 ft
4.5–6 m

BLAINVILLE'S BEAKED WHALE
Mesoplodon densirostris
An arched lower jaw and flattened forehead make this widespread species one of the more easily recognized beaked whales.

16–20 ft
5–6 m

STRAP-TOOTHED WHALE
Mesoplodon layardii
This is a boldly marked species from the Southern Hemisphere. The male has long, curved teeth, which can meet over the upper jaw.

16–18 ft
5–5.5 m

HUBBS' BEAKED WHALE
Mesoplodon carlhubbsi
Presumed to inhabit the North Pacific, but rarely seen, this species has white patches on its beak and head. The male has two prominent teeth.

15–16 ft
4.7–5 m

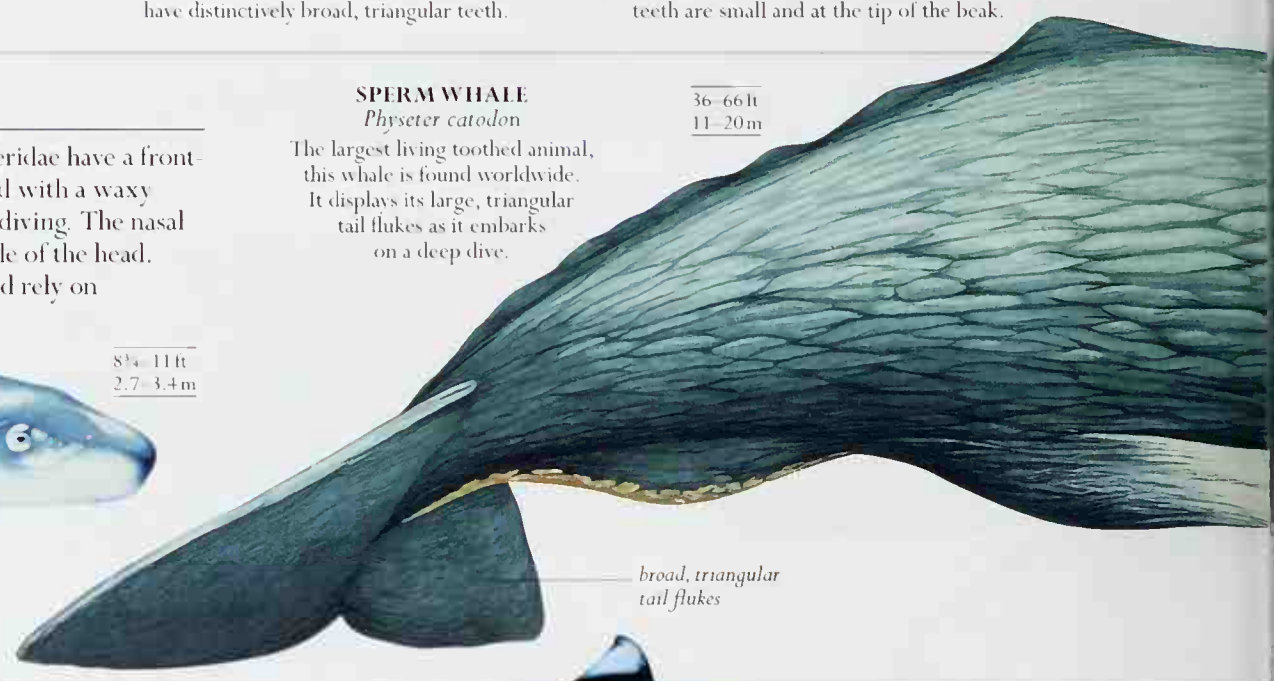
GINKGO-TOOTHED BEAKED WHALE
Mesoplodon ginkgodens
This species is known mainly from strandings (washing ashore on beaches) in the Pacific and Indian oceans. The males have distinctively broad, triangular teeth.

15–16 ft
4.5–5 m

GERVAIS' BEAKED WHALE
Mesoplodon europaeus
This slender whale is seen most often around the Canary Islands in the Atlantic Ocean. The male's teeth are small and at the tip of the beak.

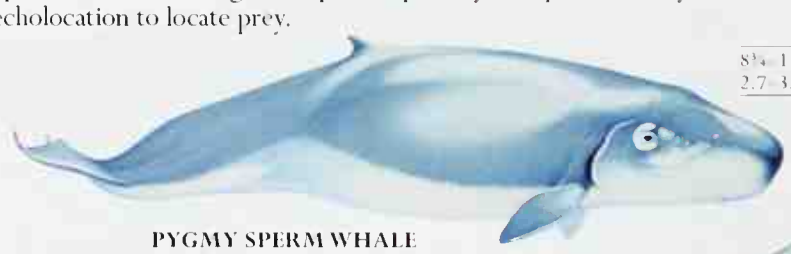
SPERM WHALES

With a small lower jaw and rounded forehead, the Physeteridae have a front-heavy appearance. Their large heads include an organ filled with a waxy substance called spermaceti oil that acts as a ballast while diving. The nasal bones are asymmetrical, and the blowhole is on the left side of the head. Sperm whales feed at great depths, especially on squid, and rely on echolocation to locate prey.



36–66 ft
11–20 m

SPERM WHALE
Physeter catodon
The largest living toothed animal, this whale is found worldwide. It displays its large, triangular tail flukes as it embarks on a deep dive.



8¾–11 ft
2.7–3.4 m

PYGMY SPERM WHALE
Kogia breviceps
One of the smallest whales, this species is an inhabitant of deep temperate and tropical waters. It is known mainly from strandings.

PORPOISES

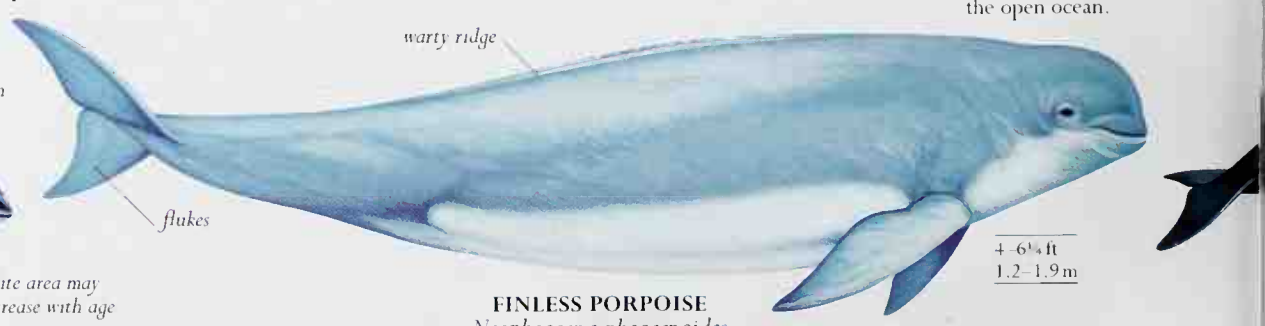
Generally smaller but stouter than dolphins, the Phocoenidae have a small, rounded head and blunt jaws. The dorsal fin is triangular rather than curved. Most distinctively, porpoises have flattened, spade-shaped teeth. Active predators of fishes, squid, and crustaceans, porpoises use sound to find prey and communicate. The six species occur mainly in shallow coastal waters.

5½–7¼ ft
1.7–2.2 m

DALL'S PORPOISE
Phocoenoides dalli
This highly active porpoise from the North Pacific has a stout, bicolored body and a small head. It prefers the open ocean.

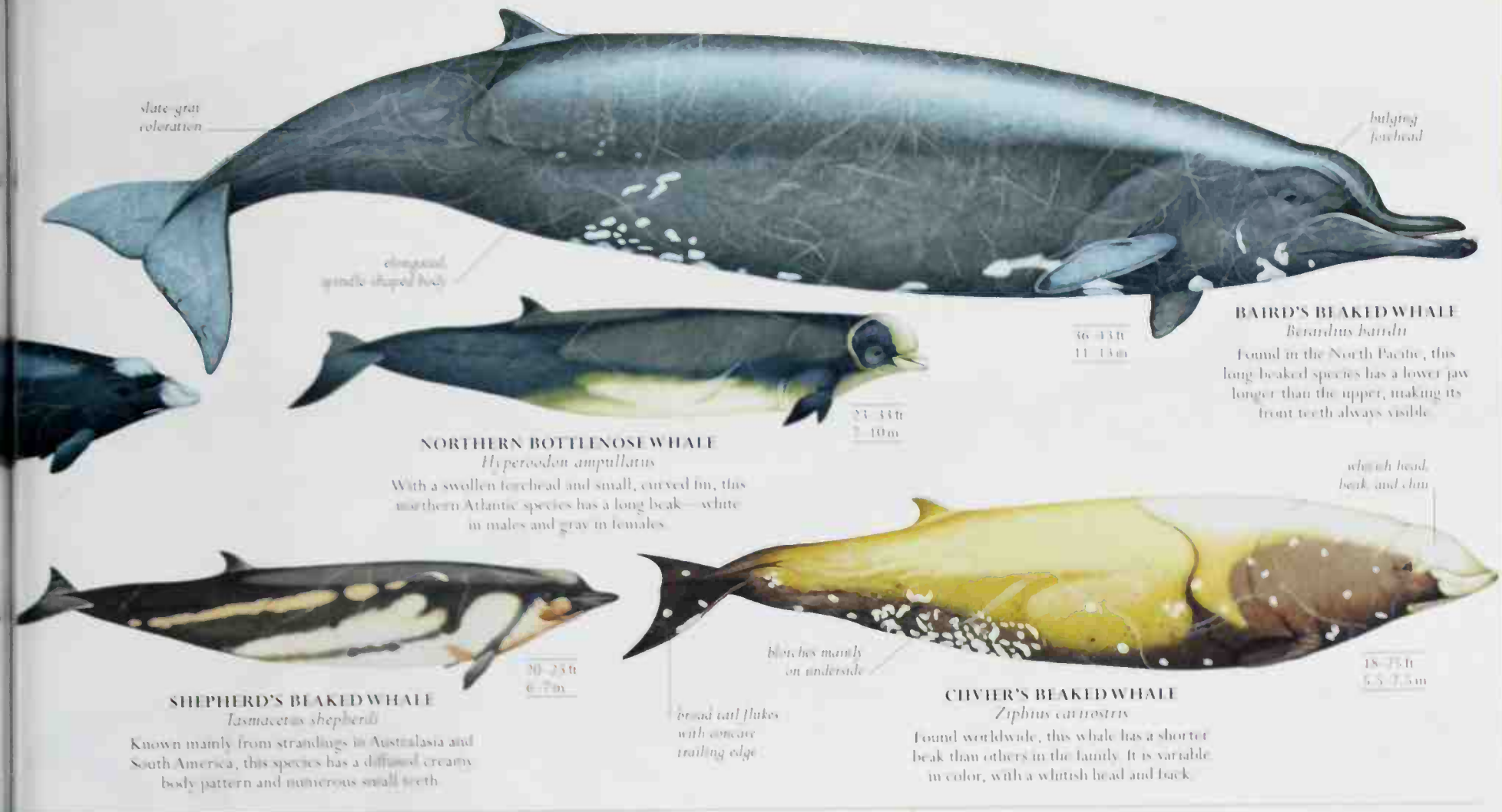
4¼–7¼ ft
1.3–2.2 m

SPECTACLED PORPOISE
Australophocaena dioptrica
Although rarely seen in its sub-Antarctic range, this species is readily recognized by its sharply demarcated colors. The upper blue-black skin makes it difficult to see from above.



4–6¼ ft
1.2–1.9 m

FINLESS PORPOISE
Neophocaena phocaenoides
Found throughout Asian coastal waters, including a freshwater population in China, this porpoise has a low warty ridge instead of a dorsal fin.


slate-gray coloration
elongated, spindle-shaped body
bulging forehead
46–43 ft
11–13 m
BAIRD'S BEAKED WHALE
Berardius bairdii
Found in the North Pacific, this long-beaked species has a lower jaw longer than the upper, making its front teeth always visible.
23–33 ft
7–10 m
NORTHERN BOTTLENOSE WHALE
Hyperoodon ampullatus
With a swollen forehead and small, curved fin, this northern Atlantic species has a long beak—white in males and gray in females.
whitish head, beak, and chin
blotches mainly on underside
broad tail flukes with concave trailing edge
20–23 ft
6–7 m
SHEPHERD'S BEAKED WHALE
Tasmacetus shepherdi
Known mainly from strandings in Australasia and South America, this species has a diffused creamy body pattern and numerous small teeth.
18–25 ft
5.5–7.5 m
CUVIER'S BEAKED WHALE
Ziphius cavirostris
Found worldwide, this whale has a shorter beak than others in the family. It is variable in color, with a whitish head and back.

NARWHAL AND BELUGA

The Monodontidae form a small family of two medium-sized Arctic whales that are rather unusual in appearance. They are highly gregarious species and are found in bays, estuaries, and fjords, and along the edges of pack ice, sometimes in herds of several hundred. Neither species has a true dorsal fin; both have a swollen, rounded forehead, which can change shape when they produce sounds, of which they have a wide range.

NARWHAL
Monodon monoceros
Mottled gray and brown in color, the narwhal has only two teeth, one of which grows into a twisted tusk up to 9 ft (3 m) long in adult males.

HARBOR PORPOISE
Phocoena phocoena
Widespread across the Northern Hemisphere, the harbor porpoise is one of the most familiar cetaceans. Often found in estuaries, it sometimes ventures upriver.

BURMEISTER'S PORPOISE
Phocoena spinipinnis
This dark porpoise, with a distinctive backward-pointing dorsal fin, is one of the most abundant cetaceans around the coasts of South America.

VAQUITA
Phocoena sinus
Unique to the Sea of Cortez (Gulf of California), this is the smallest and rarest porpoise, often inhabiting lagoons so shallow that its back protrudes above the surface.

BELUGA
Delphinapterus leucas
The beluga has a circumpolar distribution in Arctic and subarctic waters, spending the winter around and under pack ice. It is the only whale entirely white as an adult.

OCEANIC DOLPHINS

Found worldwide, often in shallow seas over continental shelves, the Delphinidae typically have a curved dorsal fin, protruding beak, and swollen forehead. Small- to medium-sized, their colors and patterns vary widely. Most mainly eat fish and travel in herds or "pods." Larger species are collectively known as blackfish.

5¼–6 ft
1.6–1.8 m

HOURGLASS DOLPHIN
Lagenorhynchus cruciger
Rarely seen, this sub-Antarctic dolphin has two white flank lobes. It frequently associates with fin whales, and was valued by whalers, who used the dolphins to locate the whales.

8¼–9¼ ft
2.5–2.8 m

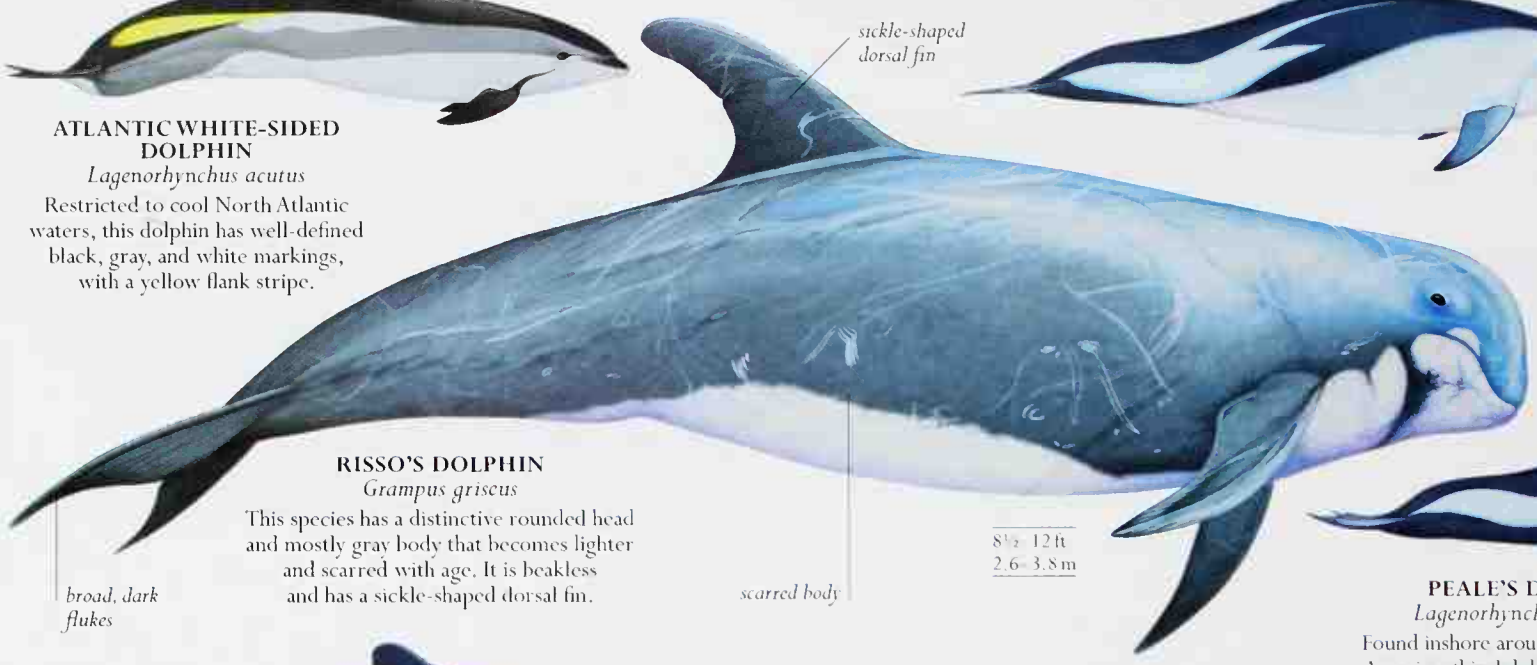
WHITE-BEAKED DOLPHIN
Lagenorhynchus albirostris
Highly acrobatic, this North Atlantic species frequently rides the bow wave of boats. It has a deeply curved dorsal fin and a thick, whitish beak.

6¼–8¼ ft
1.9–2.5 m

ATLANTIC WHITE-SIDED DOLPHIN
Lagenorhynchus acutus
Restricted to cool North Atlantic waters, this dolphin has well-defined black, gray, and white markings, with a yellow flank stripe.

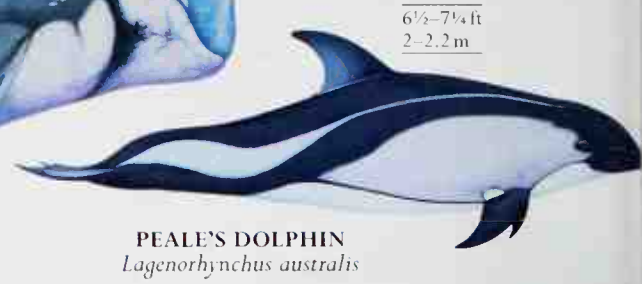
5¼–7 ft
1.6–2.1 m

DUSKY DOLPHIN
Lagenorhynchus obscurus
Widely distributed in coastal waters across the Southern Hemisphere, this is a gregarious and highly acrobatic dolphin, frequently leaping as it feeds.



8½–12 ft
2.6–3.8 m

RISSO'S DOLPHIN
Grampus griseus
This species has a distinctive rounded head and mostly gray body that becomes lighter and scarred with age. It is beakless and has a sickle-shaped dorsal fin.

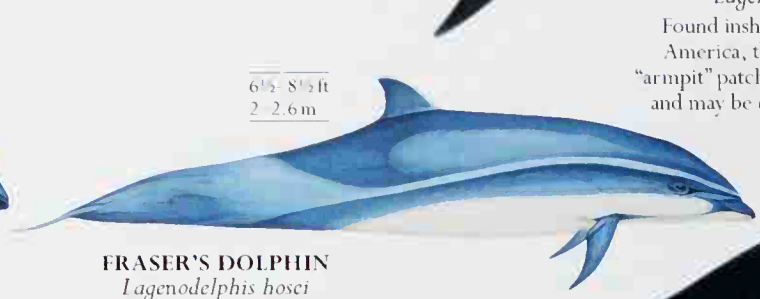


6½–7¼ ft
2–2.2 m

PEALE'S DOLPHIN
Lagenorhynchus australis
Found inshore around southern South America, this dolphin shares its white "armpit" patch with *Cephalorhynchus* species, and may be closely related to that genus.

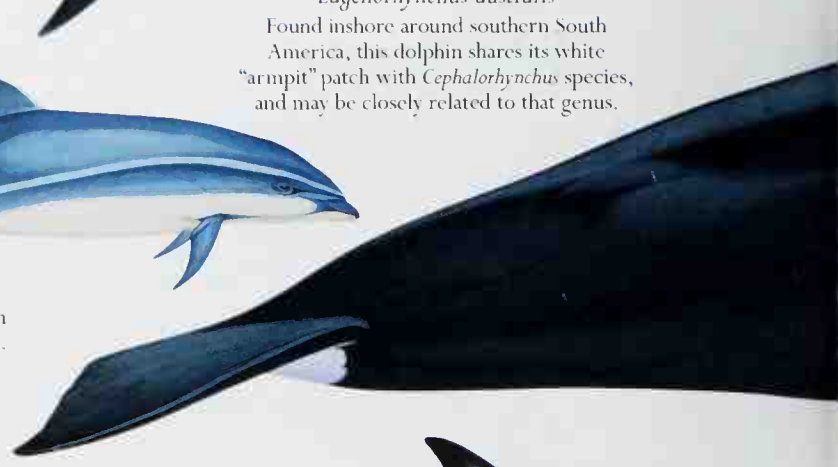
4¼–5½ ft
1.3–1.7 m

COMMERSON'S DOLPHIN
Cephalorhynchus commersonii
A small, piebald, beakless dolphin from the waters around southern South America and the Indian Ocean, this excellent swimmer and jumper has broad, blunt tail flukes.



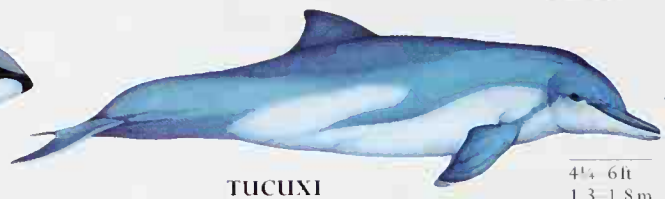
6½–8½ ft
2–2.6 m

FRASER'S DOLPHIN
Lagenodelphis hosei
This highly gregarious species is found in deep water in the Southern Hemisphere. Its flippers, fin, and beak are small in proportion to its stocky body.



4–5 ft
1.2–1.5 m

HECTOR'S DOLPHIN
Cephalorhynchus hectori
Found only in New Zealand waters, Hector's dolphin is the smallest member of its family. It has a rounded dorsal fin with an undercut rear margin.



4¼–6 ft
1.3–1.8 m

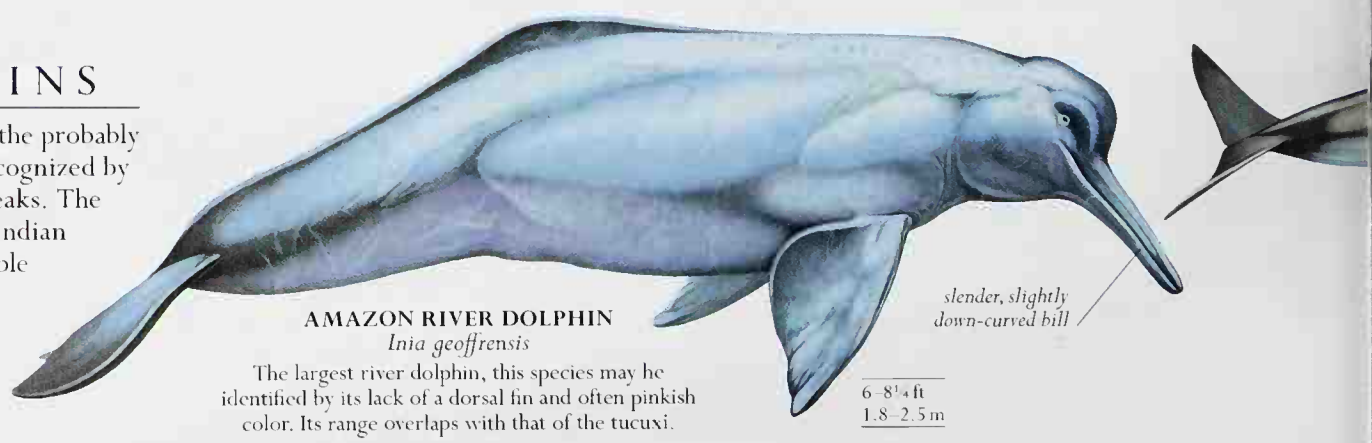
TUCUXI
Sotalia fluviatilis
Although inhabiting rivers in the Amazon basin, the tucuxi is related to oceanic species, not true river dolphins. It resembles a small bottlenose dolphin.

5½–7¾ ft
1.7–2.4 m

SHORT-BEAKED COMMON DOLPHIN
Delphinus delphis
Often forming large groups, this dolphin has a characteristic hourglass flank pattern, which can be easily seen when it leaps out of the water.

RIVER AND ESTUARINE DOLPHINS

The family Iniidae has three species, including the probably extinct Chinese river dolphin, which can be recognized by their small eyes, bulging foreheads, and long beaks. The Iniidae share their long, slender beak with the Indian river dolphins, although their teeth are not visible when the mouth is closed.



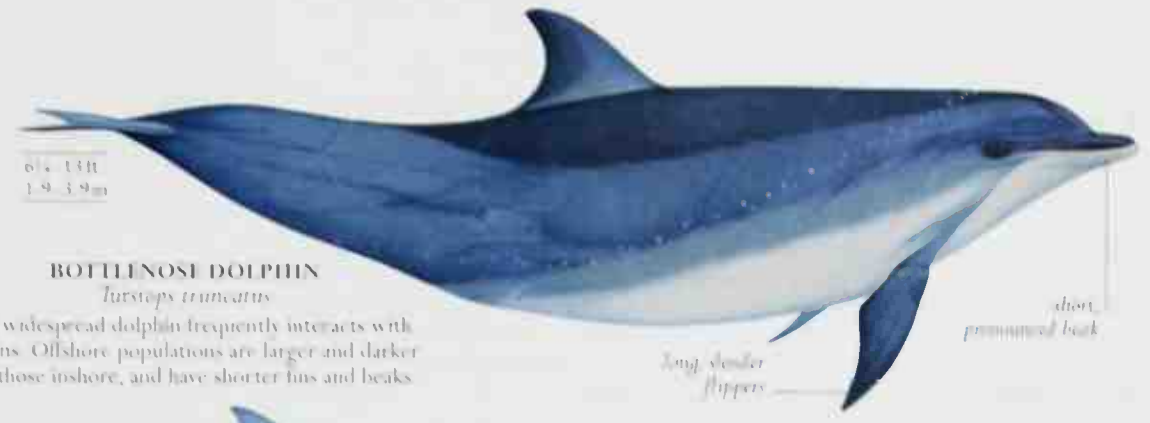
6–8¼ ft
1.8–2.5 m

AMAZON RIVER DOLPHIN
Inia geoffrensis
The largest river dolphin, this species may be identified by its lack of a dorsal fin and often pinkish color. Its range overlaps with that of the tucuxi.

7–8½ ft
2.1–2.6 m

ROUGH-TOOTHED DOLPHIN
Steno bredanensis

Occurring in most warm waters, this species has a conical head that extends into a long, slender beak, and a broad-based, pointed dorsal fin.



6¼–13 ft
1.9–3.9 m

BOTTLENOSE DOLPHIN
Tursiops truncatus

This widespread dolphin frequently interacts with humans. Offshore populations are larger and darker than those inshore, and have shorter fins and beaks.

5½–7½ ft
1.7–2.3 m

ATLANTIC SPOTTED DOLPHIN
Stenella frontalis

From the tropical and subtropical Atlantic, this dolphin has dark spots below and pale spots above. These increase in density as it matures.

6–8½ ft
1.8–2.5 m

STRIPED DOLPHIN
Stenella coeruleoalba

Found in temperate and tropical parts of all oceans, this acrobatic species has a distinctive pattern of blue stripes and wedges.

6–9½ ft
1.8–2.9 m

SOUTHERN RIGHT WHALE DOLPHIN
Lissodelphis peronii

Within its range, the only dolphin to lack a dorsal fin, this distinctive black and white species occurs throughout the cool oceans of the Southern Hemisphere.

15–33 ft
5.5–10 m

KILLER WHALE
Orcinus orca

Boldly marked, with a tall dorsal fin, this species is at the top of marine food chain. It feeds on fishes, seals, sharks, and other cetaceans.

14–20 ft
4.3–6 m

FALSE KILLER WHALE
Pseudorca crassidens

This uniformly dark species is widespread in shallow temperate and tropical waters. It feeds on cetaceans and large fishes, often from fishing nets.

7–8½ ft
2.1–2.7 m

MELON-HEADED WHALE
Peponocephala electra

An offshore tropical species, this whale has a rounded head and a tall, pointed dorsal fin. It is uniformly gray, with a darker face mask.

7–8½ ft
2.1–2.6 m

PYGMY KILLER WHALE
Feresa attenuata

Lacking a beak, this small, dark, robust species can be very aggressive. It kills and eats other dolphins within its circumtropical range.

11–23 ft
3.5–7 m

LONG-FINNED PILOT WHALE
Globicephala melas

Prone to mass stranding, this social species is widespread in temperate waters. Its bulbous forehead can be seen as it lifts its head out of the water to look around.

4–5 ft
1.2–1.5 m

FRANCISCANA
Pontoporia blainvillei

Although inhabiting estuaries and coastal waters of eastern South America, this species is in the river dolphin family. It has, proportionally, the longest beak of any cetacean.

INDIAN RIVER DOLPHINS

The sole species in the family Platanistidae has two virtually identical subspecies in the Indus and Ganges rivers. Their long teeth are visible even when the mouth is closed. Their tiny eyes lack lenses and they are effectively blind.

7–8½ ft
2.1–2.5 m

INDUS RIVER DOLPHIN
Platanista minor

From gray to pale blue to brown, this dolphin has a distinctive long beak, large flippers, and triangular dorsal hump. It navigates and hunts using echolocation.

GLOSSARY

ABDOMEN
The hind part of the body. The abdomen lies below the ribcage in mammals, and behind the thorax in arthropods.

ACCESSORY FRUIT
A fruit that is formed from the flower's ovary and another structure, such as the swollen base of the flower. Examples of accessory fruits are apples and figs.

ADIPOSE FIN
A small fin in fishes behind the dorsal fin. It is mostly fatty tissue covered with skin.

AGARIC
Mushroomlike fruitbody of a fungus, consisting of stem and cap.

ALKALOID
Bitter, sometimes poisonous, chemical produced by certain plants and fungi.

ALLUVIAL (DEPOSIT)
Concentrations of material that have been separated by weathering from the host rock, then deposited in rivers or streams.

AMPHIBOLE
Group of common rock-forming minerals, often with complex composition. Most are ferromagnesian silicates.

ANAL FIN
The unpaired fin of a fish on the lower side of its body, behind the anus.

ANGIOSPERM
A seed-producing plant that encloses its seeds in a fruit and produces flowers.
See also gymnosperm.

ANNUAL
A plant that completes its life cycle, from germination to death, in a single season of growth.

ANTENNA (PL. ANTENNAE)
A sensory feeler on the head of arthropods and some other invertebrates, such as mollusks. Antennae are always present in pairs, and can be sensitive to touch, sound, heat, and taste. Their size and shape varies widely according to the way in which they are used.

ANTHER
In flowering plants, the podlike structure on the stamen that produces pollen.

ANTLER
A bony growth on the head of deer. Unlike horns, antlers often branch, and in most cases they are grown and shed every year in a cycle linked with the breeding season.

ARBOREAL
Living fully or partly (known as semiarboreal) in trees.

ASCUS (PL. ASCI)
Microscopic saclike structure of sac fungi (Ascomycota) that produces spores.

ASEXUAL REPRODUCTION
A form of reproduction that involves just one parent, producing offspring that are genetically identical to each other (clones). It is most common in microbes, plants, and invertebrates.

BALEEN
A fibrous substance used by some whales for filtering food from water. Baleen grows in the form of plates with frayed edges, which hang from a whale's upper jaw. The baleen plates trap food, which the whale then swallows.

BASAL ANGIOSPERM
Order of flowering plant with certain primitive features that diverged away from the main evolutionary line of flowering plants before others. It includes water lilies.

BASIDIUM (PL. BASIDIA)
Microscopic clublike structure of mushrooms and relatives (Basidiomycota) that produces spores.

BEAK
A set of narrow protruding jaws, usually without teeth. Beaks have evolved separately in many groups of vertebrates, including birds, tortoises, and some whales. The beak of a bird is also called a bill.

BERRY
A fleshy many-seeded fruit of a plant that develops from a single ovary. Many fruits popularly called berries are not true berries but compound fruits—an example of which is raspberry.

BIENNIAL
A plant that completes its life cycle, from germination to death, in two years. It typically stores up food in the first season that can be used for reproduction in the second season.

BIOLUMINESCENCE
The production of light by living organisms.

BIPEDAL
An animal that moves on two legs.

BRACKET
Shelflike fruitbody of a fungus.

BRACT
Modified leaf, often brightly colored, beneath a flower or flower cluster.

BROMELIAD
Flowering plant of the family Bromeliaceae. Almost exclusively tropical American, most live as rain forest epiphytes: perched in the rain forest branches without getting nourishment from the trees. Many form rosettes of leaves that collect rainwater, forming treetop pools that are important nurseries of insect larvae and frog tadpoles.

BROWSER
An animal that feeds on the leaves of trees and shrubs rather than on grasses.

BULB
The underground shoot of a plant, consisting of modified leaves and used for food storage during periods of dormancy or for asexual reproduction.

CALYX
Outer cuplike whorl of a flower, made up of sepals.

CAMOUFLAGE
Colors or patterns that enable an animal to merge with its background. It is often used for protection against predators and for concealment when approaching prey.

CANINE (TOOTH)
In mammals, a tooth with a single sharp point that is shaped for piercing and gripping prey. Canine teeth are located toward the front of the jaws, and are highly developed in carnivores.

CARAPACE
A hard shield found on the back of the bodies of animals, invertebrates, and crustaceans. In turtles and tortoises the carapace is the upper part of the shell.

CARBOHYDRATE
Foodstuff, such as sugar or starch, that provides energy.

CARNASSIAL (TOOTH)
In mammalian carnivores, a bladelike upper premolar and lower molar tooth that have evolved for slicing through flesh.

CARNIVORE
Any animal that eats meat. The word carnivore can also be used in a more restricted sense to mean mammals of the order Carnivora.

CARPEL
Female reproductive part of a flower, divided into ovary, style, and stigma. Also known as the pistil.

CARTILAGE
A rubbery substance forming part of vertebrate skeletons. In most vertebrates, it lines the joints, but in cartilaginous fish it forms the whole skeleton.

CATKIN
Hanging cluster of flowers, usually with simple flowers all of the same sex.

CECUM
Pouch of the digestive tract, often used in the digestion of plant food.

CELL
The smallest unit of an organism that can exist on its own.

CELLULOSE
A complex carbohydrate found in plants. It is used by plants as building material, and has a resilient chemical structure that animals find hard to digest. Plant-eating animals break it down in their stomach with the aid of microorganisms.

CHITIN
A tough carbohydrate making up cell walls of fungi and certain animal exoskeletons.

CHLOROPHYLL
Green pigment found in chloroplasts used to trap light energy in photosynthesis.

CHLOROPLAST
Granule inside the cell of a photosynthesizing eukaryote used for photosynthesis. *See* photosynthesis.

CHROMOSOME
Microscopic filament inside a cell that carries genetic information (DNA).

CLIMBER
A plant that grows up a vertical surface, such as a rock or a tree, using it for support. Climbers do not gain nourishment from other plants, and may weaken them by blocking out light.

CLOACA
An opening toward the rear of the body that is shared by several body systems. In some vertebrates—such as bony fish and amphibians—the gut, kidneys, and reproductive systems all use this opening, mainly for waste.

CLONES
Genetically identical individuals. Two or more identical organisms that share exactly the same genes.

CLOVEN-HOOFED
Having hooves that look as though they are split in half. Most cloven-hooled mammals, such as deer and antelope, actually have two hooves, arranged on either side of a line that divides the foot in two.

COCOON
A case made of open, woven silk. Many insects spin a cocoon before they begin pupation, and many spiders spin one to hold their eggs.

COLONY
A group of animals belonging to the same species that spend their lives together, often dividing up the tasks involved in survival. In some colonial species, particularly aquatic invertebrates, the colony members are permanently fastened together. In others, such as ants, bees, and wasps, members forage for food independently but live in the same nest.

COMMENSAL
Living in close relationship with an another species without either helping or damaging it.

COMPOUND
A substance made up of two of more elements chemically reacted together.

COMPOUND EYE
An eye that is divided into separate compartments, each with its own set of lenses. The number of compartments they can contain varies from a few dozen to thousands. Compound eyes are a common feature of arthropods.

COMPOUND LEAF
A leaf with a blade divided into smaller leaflets.
See also simple leaf.

CONE
The reproductive structure of a plant consisting of a cluster of scales or bracts used for producing spores, ovules, or pollen. Cones are found on various trees, particularly pine trees.

CORM
The underground storage organ of a plant, formed from a swollen stem base.

COROLLA
Inner whorl of a flower made up of petals.

CRYPTIC (COLORATION)
Coloration and markings that make an animal hard to see against its background.

CRYSTAL
A solid that has a definite internal atomic structure, producing a characteristic external shape and certain physical and optical properties.

CYTOPLASM
The jellylike interior of a cell. In the cells of eukaryotes it is restricted to the region around the nucleus.

DECIDUOUS
A plant that seasonally loses its leaves. For instance, many temperate plants lose their leaves in winter.

DELAYED IMPLANTATION
In mammals, a delay between the fertilization of an egg and the subsequent development of an embryo. This delay allows birth to occur when conditions, such as food availability, are favorable for raising young.

DNA (DEOXYRIBONUCLEIC ACID)
The chemical substance found in the cells of all living organisms that determines their inherited characteristics.

DICOTYLEDON (DICOT)
Group of flowering plants with two cotyledons (seed leaves).

DIOECIOUS
A plant that has male and female parts on different individuals.

DOMESTICATED
An animal that lives fully or partly under human control. Some such animals look identical to their counterparts in the wild, but many have been bred to produce artificial varieties not found in nature.

DORSAL FIN
The unpaired fin of a fish. The dorsal fin is located on the fish's back.

ECHOLOCATION
A method of sensing nearby objects by using pulses of high-frequency sound. Echoes bounce back from obstacles and other animals, allowing the sender to build up a picture of its surroundings. It is used by some bats, cave-dwelling birds, and marine mammals.

ECLIPSE PLUMAGE
In some birds, particularly waterfowl, an unobtrusive plumage adopted by the males once the breeding season is over.

ECOSYSTEM
A collection of species living in the same habitat, together with their physical surroundings.

ECTOPARASITE
An organism that lives parasitically on the surface of another organism's body. Some animal ectoparasites spend all their lives on their hosts, but many—including fleas and ticks—develop elsewhere and climb onto the host in order to feed.

ECTOTHERMIC
Having a body temperature that is dictated principally by the temperature of the surroundings. Ectothermic is also known as cold-blooded.

ELEMENT
Chemical substance that cannot be broken down into a simpler chemical form.

EMBRYO
A young animal or plant at a rudimentary stage of development.

ENDEMIC
A species native to a particular geographic area, such as an island, forest, mountain, state, or country, and which is found nowhere else.

ENDOPARASITE
An organism that lives parasitically inside the body of another organism, either feeding directly on its tissues or stealing some of its food. Endoparasites frequently have complex life cycles involving more than one host.

ENDOSKELETON
An internal skeleton, typically made of bone. Unlike an exoskeleton, this kind of skeleton can grow with the rest of the body.

ENDOTHERMIC
Able to maintain a constant, warm body temperature, regardless of external conditions. Also known as warm-blooded.

ENZYME
A group of substances produced by all living things that promotes a chemical process, such as photosynthesis or digestion.

EPIPHYTE
A plant or plantlike organism (such as alga or lichen) that lives on the body of another plant without getting any nourishment from it.

EUDICOTYLEDON (EUDICOT)
Any one of the higher dicotyledon flowering plant orders that together contain the majority of flowering plants.

EUKARYOTE
An organism whose cells have a nucleus. Protists, fungi, plants, and animals are eukaryotes.

EVAPORITE (DEPOSIT)
Sedimentary rock or mineral resulting from the evaporation of water from mineral-bearing fluids, usually seawater.

EVERGREEN
A plant that does not lose its leaves seasonally. An example is conifer.

EXTERNAL FERTILIZATION
In reproduction, a form of fertilization that takes place outside the female's body, usually in water, for example among coral.

EXOSKELETON
An external skeleton that supports and protects an animal's body. The most complex exoskeletons, formed by arthropods, consist of rigid plates that meet at flexible joints. This kind of skeleton cannot grow, and has to be shed and replaced at periodic intervals.

FERAL
An animal that comes from domesticated stock but which has subsequently taken up life in the wild. Examples include city pigeons, cats, and horses.

FERTILIZATION
The union of an egg cell and sperm, which creates a cell capable of developing into a new organism.

FLAGELLUM (PL. FLAGELLA)
A whiplike structure of a cell used for propulsion. It is the main structure of locomotion in flagellate protoctists.

FLOWER
Reproductive structure of the largest group of seed plants, typically consisting of sepals, petals, stamens, and carpels.

FOOD CHAIN
A series of organisms, each of which is eaten by the next.

FOSSIL
Any record of past life preserved in Earth's crust. They include bones, shells, footprints, excrement, and ground borings.

FRUIT
A fleshy structure of a plant that develops from the ovary of the flower and contains one or more seeds. Fruits can be simple, like berries, or compound, where the fruits of separate flowers are merged. *See also* accessory fruit.

FRUITBODY
Fleshy spore-producing structure of a fungus, typically in the shape of a mushroom (agaric) or bracket.

GALL
A tumorlike growth in a plant that is induced by another organism (such as a fungus or an insect). By triggering the formation of galls, animals provide themselves with a safe hiding place and a convenient source of food.

GAMETE
A sex cell. In animals, this is either a sperm cell or an unfertilized egg cell.

GENE
The basic unit of heredity in all living things, typically a segment of DNA that provides the coded instructions for a particular protein.

GERMINATION
Developmental stage where a seed or a spore begins to grow.

GESTATION (PERIOD)
Length of time from fertilization to birth in a live-bearing animal.

GILL
In fish, amphibians, crustaceans, and mollusks, an organ used for extracting oxygen from water. Unlike lungs, gills are outgrowths of the body. In fungi, gills are the bladelike spore-producing structures under the cap of agaric fungi.

GRAZER
An animal that feeds on grass or algae.

GYMNOSPERM
A seed plant that doesn't enclose its seeds in a fruit. Many gymnosperms carry their seeds on cones. *See also* angiosperm.

HERB (HERBACEOUS PLANT)
A nonwoody plant, usually much shorter than shrubs or trees.

HERBIVORE
An animal that feeds on plants or algae.

HERMAPHRODITE
An organism that has both male and female sex organs.

HIBERNATION
A period of dormancy in winter. During hibernation, an animal's body processes drop to a low level to conserve energy.

HORMONE
A chemical signal produced by one part of the body that changes the behavior of another part of the body.

HORN
In mammals, a pointed growth on the head. True horns are hollow, and are often curved.

HOST
An organism on or in which a parasite, or symbiont, feeds.

HYDROTHERMAL VEIN
Sheet-shaped mass of material altered or deposited by water heated by igneous activity in rock.

HYPHA (PL. HYPHAE)
Microscopic threadlike structure making up the body of a fungus. Many such hyphae make up a mass that is known as a mycelium.

IGNEOUS ROCK
Rock formed from erupted volcanic lava or solidified magma.

INCISOR (TOOTH)
In mammals, a flat tooth at the front of the jaw that is shaped for slicing or gnawing.

INCUBATION
In birds, the period when a parent sits on the eggs and warms them, allowing them to develop. Incubation periods range from under 14 days in several species.

INFLORESCENCE
A flower cluster or a single flower.

INORGANIC
Chemical substance that is not based on the element carbon.

INSECTIVORE
An animal that feeds on insects.

INTERNAL FERTILIZATION
In reproduction, a form of fertilization that takes place inside the female's body. Internal fertilization is a characteristic of many land animals, particularly including insects and vertebrates.

KEEL
In birds, an enlargement of the breastbone that is anchored to the muscles that are used in flight.

KERATIN
A tough structural protein found in hair, claws, and horns.

LARVA (PL. LARVAE)
An immature but independent animal that looks completely different from an adult of the species. A larva develops the adult shape by metamorphosis; in many insects, the change takes place in a resting stage that is called a pupa.

LAVA
Molten rock that has erupted from a volcano, and then hardens.

LEGUME
Plants of the pea family of flowering plants, the Fabaceae. They are important because they have root nodules that contain nitrogen-fixing bacteria.

LEK
A communal display area used by male animals (particularly birds) during courtship. The same location is often revisited for many years.

LICHEN
Mutualistic association between a fungus and a photosynthetic algae. From this relationship, the fungus obtains sugars, and the alga obtains minerals.

LIFE CYCLE
The developmental sequence of an organism from gametes (sex cells) to death.

LOCOMOTION
Movement from place to place.

LUSTER
The shine or look of a mineral due to the reflection of light off its surface.

MAGMA
Rock in a molten state and lying below Earth's surface.

MAGNOLIIDAE
Group of flowering plants consisting of orders with certain primitive characteristics, such as undifferentiated tepals instead of sepals and petals.

MANDIBLE
The paired jaws of an arthropod, or, in vertebrates, the bone that makes up all or part of the lower jaw.

METABOLISM
The complete array of chemical processes that takes place inside an animal's body. Some of these processes release energy by breaking down food, while others use energy, for example, by making the body's muscles contract.

METAMORPHIC ROCK
Rock that has been changed by heat, pressure, or both to form new rock consisting of new minerals.

METAMORPHOSIS
A change in body shape undergone by many animals — particularly invertebrates — as they grow from being a juvenile to an adult. In insects, metamorphosis can be complete or incomplete. Complete metamorphosis involves a total shape change during a resting stage, which is called a pupa. Incomplete metamorphosis involves a series of less drastic changes, and these occur each time the young animal molts.

MIGRATION
A journey undertaken to a different region, following a well-defined route. Most migratory animals move with the seasons to take advantage of good breeding conditions in one place, and a suitable wintering climate in another.

MIMICRY
A form of camouflage in which an animal resembles another animal or an inanimate object, such as a twig or a leaf. Mimicry is very common in insects, with many harmless species imitating ones that have dangerous bites or stings.

MINERAL
An inorganic, naturally occurring material with a constant chemical composition and regular internal atomic structure.

MITOCHONDRION (PL. MITOCHONDRIA)
Granule inside the cell of a eukaryote used for respiration. Mitochondria use up oxygen to release energy.

MOLAR (TOOTH)
In mammals, a tooth at the rear of the jaw. Molar teeth often have a flattened or ridged surface, and deep roots. They are normally used for chewing.

MONOCOTYLEDON (MONOCOT)
Group of flowering plants with a single seed leaf (cotyledon).

MONOECIOUS
A plant that has separate male and female parts on the same individual.

MONOGAMOUS
Mating with a single partner, either during the course of one breeding season or throughout life. Monogamous partnerships are common in animals that care for the development of their young.

MOLT
The shedding of fur, feathers, or skin so that it can be replaced. Mammals and birds molt to keep their fur and feathers in good condition, to adjust their insulation, or so they can be ready to breed. Arthropods, such as insects, molt their exoskeleton in order to grow.

MUTUALISM
A relationship between two different species within an ecological community where both species benefit. For instance, a flowering plant and a pollinating insect share a mutualistic relationship.

MYCELIUM
Mass of threadlike hyphae making up the body of a fungus.

MYCORRHIZA (PL. MYCORRHIZAE)
The mutualistic association between a fungus and the roots of a plant. The fungus obtains sugars, while the plant increases its mineral uptake by absorbing minerals via the fungus' extensive mycelium.

NICHE
An organism's place and role in its habitat. Although two species may share the same habitat, they never share the same niche.

NITROGEN FIXATION
A chemical process whereby atmospheric nitrogen is converted into more complex nitrogen-containing substances, such as protein. Nitrogen fixation is undertaken by certain types of microorganisms.

NODE
A swelling marking the point where two sections of a stem join. They often sprout leaves at the node.

NUCLEUS (PL. NUCLEI)
The structure inside the cell of a eukaryote that contains chromosomes.

NUT
Dry, hard-shelled fruit of some plants, usually a single seed.

NYMPH
An immature insect that looks similar to its parents but which does not have functioning wings or reproductive organs. A nymph develops its adult form by metamorphosis, changing slightly each time it molts.

OMNIVORE
An animal that eats both plants and other animals as its primary food source.

OPERCULUM
A cover or lid. In some gastropod mollusks, an operculum is used to seal the shell when the animal has withdrawn inside. In bony fish, an operculum on each side of the body protects the chamber containing the gills.

OPPOSABLE
Able to be pressed together from opposite directions. For example, many primates have opposable thumbs, which can be pressed against the other fingers so that objects can be grasped.

ORGAN
The structure of an organism that carries out a particular function. Examples are the heart, skin, or a leaf.

ORGANELLE
A specialized structure that forms part of a plant or animal cell.

ORGANIC
Chemical substance based on carbon.

OVIPAROUS
Reproducing by laying eggs.

OVIPOSITOR
An egg-laying tube extending out of the body of some female animals, especially in insects.

OVULE
Structure that contains the egg of a seed plant. These are encased in an ovary in flowering plants, but naked in gymnosperms. After fertilization the ovule becomes the seed.

PARASITE
An organism that lives on or in another host organism, gaining advantage (such as nourishment) while causing the host harm. Most parasites are much smaller than their host and have complex life cycles involving the production of huge numbers of young. Parasites often weaken their host but generally do not kill them.

PARTHENOGENESIS
A form of reproduction in which an egg cell develops into a young animal without having to be fertilized, producing offspring that are genetically identical to the parent. In animals that have separate sexes, young produced by parthenogenesis are always female. Parthenogenesis is common in invertebrates.

PECTORAL FIN
One of the two paired fins positioned toward the front of the fish's body, often just behind its head. Pectoral fins are usually highly mobile and are normally used for maneuvering.

PELVIC FIN
The rear paired fins in fish, which are normally positioned close to the underside, sometimes near the head but more often toward the tail. Pelvic fins are generally used as stabilizers.

PERENNIAL
A plant that normally lives for more than one season.

PERIANTH
The outer two whorls of a flower (the calyx, made up of sepals, and the corolla, made up of petals); especially where the two are undifferentiated.

PETAL
One of the parts of the corolla of a flower. It is often brightly colored to attract pollinating animals.

PETIOLE
The stalk of a leaf.

PHEROMONE
A chemical produced by one animal that has an effect on other members of its species. Pheromones are often volatile substances

that spread through the air, triggering a response from animals some distance away.

PHOTOSYNTHESIS
A process whereby organisms use light energy to make food and oxygen; photosynthesis occurs in plants, algae, and many microorganisms.

PLACENTA
An organ developed by an embryo animal that allows it to absorb nutrients and oxygen from its mother's bloodstream before it is born.

PLANKTON
Floating organisms, many of them microscopic, that drift in open waters, particularly near the surface of the sea. Planktonic organisms can often move, but most are too small to make any headway against strong currents. Planktonic animals are known as zooplankton. Planktonic algae are called phytoplankton.

PLASTRON
The lower part of the shell structure of tortoises and turtles.

POLLEN
Tiny grains produced by seed plants that contain male gametes for fertilizing the female egg of either a flowering plant or a coniferous plant.

POLYGAMOUS
A reproductive system in which individuals mate with more than one partner during the course of a single breeding season.

PREDATOR
An animal that catches and kills other animals, referred to as its prey. Some predators attack and catch their prey by lying in wait, but most actively pursue and attack other animals.

PREHENSILE
Able to curl around objects and grip them.

PREMOLAR (TOOTH)
In mammals, a tooth positioned midway along the jaw between the canine and the molar teeth. In carnivores, specialized premolar teeth act like shears, slicing through flesh.

PROBOSCIS
An animal's nose, or set of mouthparts with a noselike shape. In insects that feed on fluids, the proboscis is often long and slender, and can usually be stowed away when not in use.

PROKARYOTE
An organism whose cells do not have a nucleus. Examples of prokaryotes are archaea and bacteria.

PRONOTUM
The part of an insect's cuticle that covers the first segment of its thorax, often hardening into a shield.

PROTEIN
Substance found in food, such as meat, fish, cheese, and beans, that is used for growth and for carrying out a variety of biological functions.

PSEUDOPOD
Projection of a cell that can change shape. It is used for creeping forward or for catching food. It occurs in protists, such as amoebas.

PUPA (PL. PUPAE)
In insects, a stage during which the larval body is broken down and rebuilt as an adult. During the pupal stage the insect does not feed and usually cannot move, although some pupae may wriggle if they are touched. The pupa is protected by a hard case, which itself is sometimes wrapped in silk.

QUADRUPEDAL
An animal that walks on four legs.

RAPTOR
A bird of prey.

RHIZOME
A creeping or underground stem that can send out new shoots.

ROCK
Material made up of one or more minerals.

ROOT NODULE
Spherical swelling on the root of a legume that contains nitrogen-fixing bacteria.

RUMINANT
A hoofed mammal that has a specialized digestive system with several stomach chambers. One of these — the rumen — contains large numbers of microorganisms which help break down plant food. To speed this process, a ruminant usually regurgitates its food and rechews it, a process called chewing the cud.

SALLY
A bird's short flight from a perch to catch an invertebrate, often in mid-air.

SCUTE
A shieldlike plate or scale that forms a bony covering on some animals.

SEDIMENTARY ROCK
Rock formed by the consolidation and hardening of rock fragments, organic remains, or other material.

SEED
Developmental stage of a seed plant, consisting of an encapsulated embryo.

SEPAL
One of the parts of the calyx of a flower, usually small and leaflike and enveloping the unopened flower bud.

SEXUAL DIMORPHISM
Showing physical differences between males and females. In animals that have separate sexes, males and females always differ, but in highly dimorphic species, such as elephant seals, the two sexes look very different and are often unequal in size.

SHOOT
The aerial part of plant. It is a new growth usually growing upward.

SHRUB
Woody perennial plant with multiple stems.

SIMPLE LEAF
A leaf with an undivided blade.

SPERMATOPHORE
A packet of sperm that is transferred either directly from male to female, or indirectly — for example, by being left on the ground. Spermatophores are produced by a range of animals, including salamanders and some arthropods.

SPIRACLE
In rays and some insects, an opening behind the eye that lets water flow into the gills. In insects and myriapods, the spiracle is an opening on the body wall that lets air into the tracheal system.

SPORE
A single cell containing half the quantity of genetic material of typical body cells. Unlike gametes, spores can divide and grow without being fertilized. Spores are produced by fungi and plants.

SPOROPHYTE
The spore-producing stage of a plant. It is the dominant (visible) stage of ferns and seed plants.

STAMEN
Male reproductive part of a flower. It has an anther borne on a long filament.

STEREOSCOPIC (VISION)
Vision in which the two eyes face forward, giving overlapping fields of view and allowing the animal to judge distance. Also called binocular vision.

STOMA (PL. STOMATA)
Tiny adjustable pore on the surface of a plant that allows the exchange of gases for photosynthesis and respiration.

SWIM BLADDER
A gas-filled bladder that most bony fish use to regulate their buoyancy. By adjusting the gas pressure inside the bladder, a fish can become neutrally buoyant, meaning that it neither rises nor sinks.

SYMBIOSIS
Any relationship between two different species within an ecological community. Examples of symbiotic relationships are predator–prey, parasite–host, and mutualism.

TEPAL
The outer part of a flower undifferentiated into sepals and petals. Tepals collectively make up the perianth.

TERRESTRIAL
Living always or mainly on the ground.

TERRITORY
An area defended by an animal, or group of animals, against other members of the same species. Territories often include resources, such as food supply, that help the male attract a mate.

THORAX
The middle region of an arthropod's body. The thorax contains powerful muscles and, if the animal has any, bears legs and wings. The thorax is the chest in vertebrates with four limbs.

TORPOR
A sleeplike state in which body processes slow to a fraction of their normal rate. Animals usually become torpid to survive difficult conditions, such as extreme cold or lack of food.

TRACHEAL SYSTEM
A system of minute tubes that arthropods (for example, insects) use to carry oxygen into their bodies. Air enters the tubes through openings called spiracles, and then flows through the tracheae to reach individual cells.

TREE
Woody perennial plant with a single stem, known as a trunk.

UNGULATE
A hoofed mammal.

UTERUS
In female mammals, the part of the body that contains and usually nourishes developing young. In placental mammals, the young are connected to the wall of the uterus via a placenta.

VECTOR
An organism that transmits a disease-causing parasite from one host to another.

VEIL
Thin skin- or weblike tissue that protects the fruitbody of a fungus.

VESTIGIAL
Relating to an organ that is atrophied or non-functional.

VIVIPAROUS
Reproducing by giving birth to live young.

VOLVA
A sackike remnant of a veil at the base of a fungus's fruitbody stem.

WOODY PLANT
A plant that has wood — a type of strengthening tissue found in plants consisting of thick-walled water-transporting vessels.

ZYGODACTYL FEET
A specialized arrangement of the feet in which the toes are arranged in pairs, with the second and third toes facing forward and the first and fourth toes facing backward. This adaptation helps birds climb and perch on tree trunks and other vertical surfaces. Several groups of birds have zygodactyl feet, including parrots, cuckoos and turacos, owls, toucans, and woodpeckers and their relatives.

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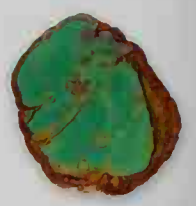
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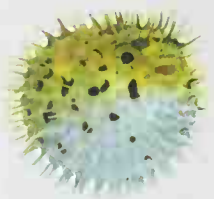
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